

# Review Questions

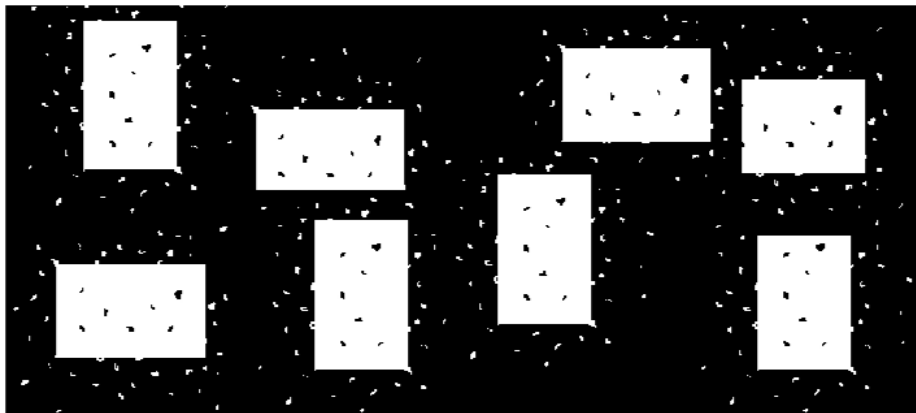
1. Describe the relationship between physical, mathematical and computational representations of images and the way they interact in the research and development of processing systems.
2. What is “signal space”? When we say that  $\mathbf{f}$  and  $\mathbf{g}$  are elements of signal space, what properties must they have? How can we treat images as elements of signal space?
3. Images can be represented in computers as arrays. Locations in arrays are determined by array coordinates ( $A[x, y, z, \dots]$ ) and array indexes ( $A[p]$ ). How does one translate between them? What information do you need to do the translation, and how do you use it?
4. Describe two approaches for the representation of color images. How does the choice affect the ability to represent color information? What are the strengths and weaknesses of each approach?
5. Given an index color image
  - (a) Give the algorithm steps to construct a true-color image.
  - (b) Give the algorithm steps to construct the intensity (gray scale) image.
  - (c) How does the gray scale image differ from the array values?
6. Given a true-color image
  - (a) Give the algorithm steps to construct an index color image.
  - (b) Give the algorithm steps to construct the intensity image.
7. Spatial structure in images is discussed with a number of concepts. How do these interact and what are some of the effects produced by different choices?
  - (a) Neighborhoods
  - (b) Paths
  - (c) Connected components
  - (d) Object connectivity (e.g. how many holes, etc.)
8. Describe the approaches to finding connected components in image arrays.
  - (a) Region labeling, and its use with arrays in which objects can have different properties, such as different colors.
  - (b) Morphological processing, in which all pixels are treated as having binary values.
  - (c) How could a binary connected components algorithm be used to find objects with different colors in an image?
  - (d) How could you use a CC algorithm to differentiate between solid objects and objects with holes?
9. Let  $A$  be an  $N \times M$  2D array of bytes and  $T$  a 1D vector with  $K$  elements. What must be the value of  $K$  so that the IDL expression  $B = T[A]$  is meaningful? What data types can be used for  $A$  for this function array approach to work?
10. Describe the uses of  $B = T[A]$  in image enhancement. For each case, describe how you would come up with the vector  $T$ . Some examples:
  - (a) Gamma correction
  - (b) Histogram equalization
  - (c) Matching image grayscales

11. Given an array  $B$  of byte values and a transformation vector  $T$  such that  $B = T[A]$  for some array  $A$ , how can you determine  $A$ ? What are the restrictions on  $T[A]$  to make this determination unambiguous? Hint: First find the histogram of  $B$  and then the histogram of  $A$ .
12. Under what conditions is the following statement true?

$$T[A + B] = T[A] + T[B]$$

$A$  and  $B$  are arrays and  $T$  is a vector of suitable length, all of integers.

13. Given images  $A$  and  $B$  and assume that the background pixels have value 0. Say what each of the following statements mean and give the IDL statement to compute it. Give another IDL statement that can be used to find the pixels in the resulting object.
  - (a)  $C = A \cup B$
  - (b)  $C = A \cap B$
  - (c)  $A^c$
  - (d)  $A - B$
14. Describe the following morphological operations for binary images and give an example of their use in image processing:
  - (a) Dilation
  - (b) Erosion
  - (c) Opening
  - (d) Closing
15. Describe an algorithm and give the IDL statements to compute the boundary of an object in a binary image.
16. Describe an algorithm and give the IDL statements for filling the hole inside a binary object.
17. Describe the elements of the hit-or-miss transform.
18. Describe an algorithm and give the IDL statements for finding the convex hull of a binary object.
19. Describe an algorithm and give the IDL statements for thinning a binary object.
20. Describe an algorithm to locate all of the large boxes in the image below.



21. The mathematical operation on an image  $\mathbf{f}$  to produce an image  $\mathbf{g}$  represented by

$$g(x, y) = \sum_{s=-a}^a \sum_{t=-b}^b w(s, t) f(x + s, y + t)$$

is the core element of linear spatially-invariant filtering. What is the corresponding statement in IDL and what are the data structures that are used?

22. Give the linear filter masks for the following operations:

- (a) Region averaging
- (b) Weighted region averaging (with pixels near the center given more weight)
- (c) Emphasizing pixels with large differences from the background
- (d) Detecting vertical (horizontal) lines
- (e) Detecting vertical (horizontal) edges
- (f) Image sharpening
- (g) Image sharpening while preserving a proportion of the original
- (h) A feature detector for hollow boxes of size  $5 \times 5$

23. What is a median filter and what is it used for?

24. Show that a median filter is not a linear filter.

25. What does the following mathematical statement mean, and how can it be implemented in a computer program? What are some of the options for its implementation? What is it used for?

$$|\nabla f| = \left[ \left( \frac{\partial f}{\partial x} \right)^2 + \left( \frac{\partial f}{\partial y} \right)^2 \right]^{1/2}$$

26. What does the following mathematical statement mean, and how can it be implemented in a computer program? What are some of the options for its implementation? What is it used for?

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

27. An image is to be segmented by a thresholding technique.

- (a) Describe a process you could use to to determine a good value for the threshold.
- (b) Describe an automated process that could determine a good value for the threshold.

28. Construct an algorithm to segment an image such as the one shown below. Describe it in outline form and draw a block diagram.

