

Tufte's books [Tuf83, Tuf90, Tuf97] show the importance of good visual design and contain considerable historical information on the development of graphics. The article by Carlbom and Paciorek [Car78] gives a good discussion of some of the relationships between classical viewing, as used in fields such as architecture, and viewing by computer.

Many books describe the human visual system. Pratt [Pra78] gives a good short discussion for working with raster displays. Also see Glassner [Gla95], Wysecki and Stiles [Wys82], and Hall [Hal89].

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## EXERCISES

- 1.1 What are the main advantages and disadvantages of the preferred method to form computer-generated images discussed in this chapter?
- 1.2 The human visual system has all the components of a physical imaging system, such as a camera or a microscope. What are the main cells or light sensors present in the human eye? List them, and explain their uses.
- 1.3 A different method of approximating a sphere starts with a regular tetrahedron, which is constructed from four triangles. Find its vertices, assuming that it is centered at the origin and has one vertex on the  $y$ -axis. Derive an algorithm for obtaining increasingly closer approximations to a unit sphere, based on subdividing the faces of the tetrahedron.
- 1.4 Consider the clipping of a point in three dimensions against a 3D rectangular clipping window or a cube. Mathematically demonstrate how the point should be clipped. Use the coordinates of the point and the equation of the plane of a 3D rectangular clipping window or a cube for your calculations.
- 1.5 Each image has a set of objects and each object comprises a set of graphical primitives. What does each primitive comprise? What are the major steps in the imaging process?
- 1.6 A display processor is a special type of processor. What are the significant advantages of display processors? Explain briefly.
- 1.7 Consider the perspective views of the cube shown in Figure 1.39. The one on the left is called a *one-point perspective* because parallel lines in one direction of the cube—along the sides of the top—converge to a *vanishing point* in the image. In contrast, the image on the right is a *two-point perspective*. Characterize the particular relationship between the viewer, or a simple camera, and the cube that determines why one is a two-point perspective and the other a one-point perspective.
- 1.8 The memory in a frame buffer must be fast enough to allow the display to be refreshed at a rate sufficiently high to avoid flicker. A typical workstation display can have a resolution of  $1400 \times 1200$  pixels. If it is refreshed 60 times per second, how fast must the memory be? That is, how much time can we take



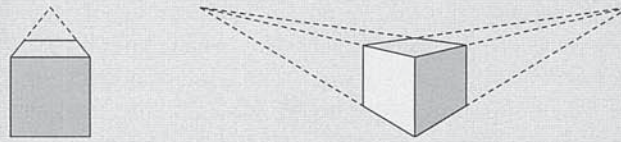


FIGURE 1.39 Perspective views of a cube.

to read one pixel from memory? What is this number for an  $800 \times 600$  display that operates at 50 Hz but is interlaced?

- 1.9 A display device has a resolution of  $800 \times 600$  pixels and uses 24 bit color for each pixel. If we generate a video with 25 frames per second which we want to upload onto the Internet, calculate the Internet speed required to transmit the video.
- 1.10 Consider the design of a two-dimensional graphical API for a specific application, such as for a power plant design. List all the primitives and attributes that you would include in your system.
- 1.11 It is possible to design a color CRT that uses a single electron gun and does not have a shadow mask. The single beam is turned on and off at the appropriate times to excite the desired phosphors. Why might such a CRT be more difficult to design, as compared to the shadow-mask CRT?
- 1.12 In a typical shadow-mask CRT, if we want to have a smooth display, the width of a pixel must be about three times the width of a triad. Assume that a monitor displays  $800 \times 600$  pixels, has a CRT diameter of 55 cm, and has a CRT depth of 27 cm. Estimate the spacing between holes in the shadow mask.
- 1.13 This interesting exercise should help you understand how to organize the graphics utilities of your display device's properties. Go to the control panel and then display properties settings. Then, change screen resolution and color quality. What changes take place in the resolution and color quality of the display device? Does your operating system allow you to change the display properties settings?