Chapter 1

Image Representation

1.1 Pixel

A digital image, or image for short, is composed of discrete pixels or picture elements. These pixels are arranged in a row-and-column fashion to form a rectangular picture area, sometimes referred to as a raster. Clearly the total number of pixels in an image is a function of the size of the image and the number of pixels per unit length (i.e. inch) in the horizontal as well as the vertical direction. This number of pixels per unit length is referred to as the resolution of the image.

Frequently image size is given as the total number of pixels in the horizontal direction tines the total number of pixels in the vertical direction. Although this convention makes it relatively straightforward to gauge the total number of pixels in an image, it does not specify the size of the image or its resolution.

The ratio of an image's width to its height, measured in unit length or number of pixels, is referred to as its aspect ratio. Both a 2×2 inch image and a 512 × 512 image has an aspect ratio of 1/1. Individual pixels in an image can be referenced by their coordinates. Typically, the pixels at the lower left corner of an image is at the origin (0, 0) of a pixel coordinate system. Thus the pixel at the lower right corner of a 640 × 480 image would have coordinates (639,0), whereas the pixel at the upper right corner would have the coordinates (639, 479).

The task of composing an image on a computer is essentially a matter of setting pixel values. The collective effects of the pixels taking on different color attributes gives us what we see as a picture.

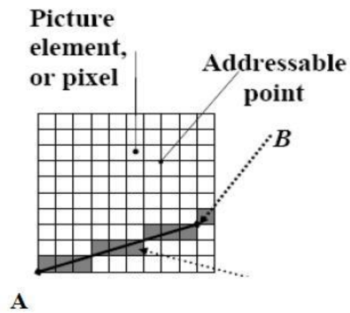

Figure 1.1 Pixel

1.1.1 Computer Graphics Image

Computer graphics can be created either by:

1. Raster Image
2. Vector Image

1.1.2 Raster Image

In computer graphics, a raster graphics or bitmap image is a dot matrix data structure that represents a generally rectangular grid of pixels (points of color), viewable via a monitor, paper, or other display medium. Raster images are stored in image files with varying formats.

A bitmap is a rectangular grid of pixels, with each pixel's color being specified by a number of bits. A bitmap might be created for storage in the display's video memory[2] or as a device-independent bitmap file. A raster is technically characterized by the width and height of the image in pixels and by the number of bits per pixel (or color depth, which determines the number of colors it can represent).

The printing and prepress industries know raster graphics as contones (from "continuous tones"). The opposite to contones is "line work", usually implemented as vector graphics in digital systems.[3] Vector images can be rasterized (converted into pixels), and raster images vectorized (raster images converted into vector graphics), by software. In both cases some information is lost, although certain vectorization operations can recreate salient information, as in the case of optical character recognition.

Raster graphics are resolution dependent, meaning they cannot scale up to an arbitrary resolution without loss of apparent quality. This property contrasts with the capabilities of vector graphics, which easily scale up to the quality of the device rendering them. Raster graphics deal more practically than vector graphics with photographs and photo-realistic images, while vector graphics often serve better for typesetting or for graphic design. Modern computer-monitors typically display about 72 to 130 pixels per inch (PPI), and some modern consumer printers can resolve 2400 dots per inch (DPI) or more; determining the most appropriate image resolution for a given printer-resolution can pose difficulties, since printed output may have a greater level of detail than a viewer can discern on a monitor.

1.1.3 Vector Image

Vector graphics are computer graphics images that are defined in terms of 2D points, which are connected by lines and curves to form polygons and other shapes Vector images are based on mathematical formulas that define geometric primitives such as polygons, lines,, curves, circles and rectangles. Each of these points has a definite position on the x- and y-axis of the work plane and determines the direction of the path; further, each path may have various properties including values for stroke color, shape, curve, thickness, and fill. Vector graphics are commonly found today in the SVG, EPS, PDF or AI graphic file formats and are intrinsically different from the more common raster graphics file formats such as JPEG, PNG, APNG, GIF, and MPEG4. Common vector formats include AI, EPS, CGM, WMF and PICT (Mac).

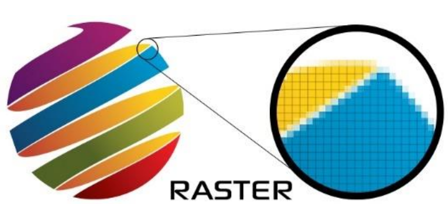

Fig 1.2: Raster Image

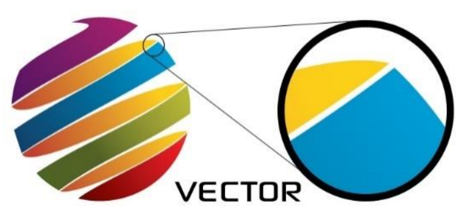

Fig 1.3: Vector Image

1.1.4 Advantages of Vector Image

Advantages to this style of drawing over raster graphics:

- Because vector graphics consist of coordinates with lines/curves between them, the size of representation does not depend on the dimensions of the object. This minimal amount of information translates to a much smaller[citation needed] file size compared to large raster images which are defined pixel by pixel. This said, a vector graphic with a small file size is often said to lack detail compared with a real-world photo.
- Correspondingly, one can infinitely zoom in on e.g., a circle arc, and it remains smooth. On the other hand, a polygon representing a curve will reveal being not really curved.
- On zooming in, lines and curves need not get wider proportionally. Often the width is either not increased or less than proportional. On the other hand, irregular curves represented by simple geometric shapes may be made proportionally wider when zooming in, to keep them looking smooth and not like these geometric shapes.
- The parameters of objects are stored and can be later modified. This means that moving, scaling, rotating, filling etc. doesn't degrade the quality of a drawing. Moreover, it is usual to specify the dimensions in device-independent units, which results in the best possible rasterization on raster devices.
- From a 3-D perspective, rendering shadows is also much more realistic with vector graphics, as shadows can be abstracted into the rays of light from which they are formed. This allows for photorealistic images and renderings.

1.2 Color Model

A color model is a system for creating a full range of colors from a small set of primary colors. A color model is an abstract mathematical model describing the way colors can be represented as tuples of numbers, typically as three or four values or color components. When this model is associated with a precise description of how the components are to be interpreted (viewing conditions, etc.), the resulting set of colors is called "color space." This section describes ways in which human color vision can be modeled.

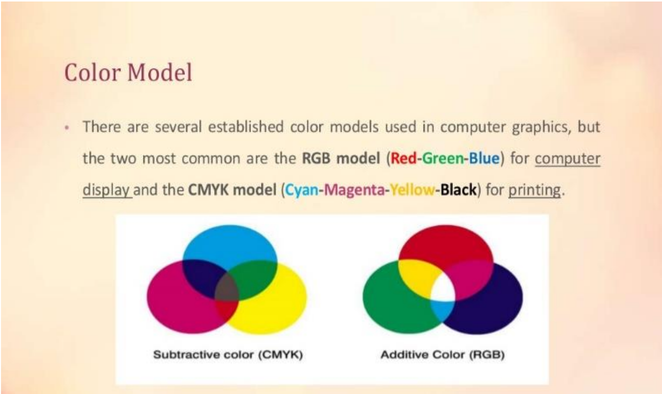

Fig 1.4: Color Models

Color models are of two types:

1.2.1 Additive Color model

Media that transmit light (such as television) use additive color mixing with primary colors of red, green, and blue, each of which stimulates one of the three types of the eye's color receptors with as little stimulation as possible of the other two. This is called "RGB" color space. Mixtures of light of these primary colors cover a large part of the human color space and thus produce a large part of human color experiences. This is why color television sets or color computer monitors need only produce mixtures of red, green and blue light. See Additive color. Other primary colors could in principle be used, but with red, green and blue the largest portion of the human color space can be captured. Unfortunately there is no exact consensus as to what loci in the chromaticity diagram the red, green, and blue colors should have, so the same RGB values can give rise to slightly different colors on different screens.

RGB Color Palette

In computer graphics, a color palette is a finite set of colors. Palettes can be optimized to improve image accuracy in the presence of software or hardware constraints.

There are two main RGB Color Palette:

1. 3-Bit RGB:

   Systems with a 3-bit RGB palette use 1 bit for each of the red, green and blue color components. That is, each component is either "on" or "off" with no intermediate states. This results in an 8-color ((21)3 = 23 = 8) palette

2. 6-Bit RGB:

   Systems with a 3-bit RGB palette use 1 bit for each of the red, green and blue color components. That is, each component is either "on" or "off" with no intermediate states. This results in an 8-color ((21)3 = 23 = 8) palette.

1.2.2 Subtractive Color model

It is possible to achieve a large range of colors seen by humans by combining cyan, magenta, and yellow transparent dyes/inks on a white substrate. These are the subtractive primary colors. Often a fourth ink, black, is added to improve reproduction of some dark colors. This is called the "CMY" or "CMYK" color space. The cyan ink absorbs red light but transmits green and blue, the magenta ink absorbs green light but transmits red and blue, and the yellow ink absorbs blue light but transmits red and green. The white substrate reflects the transmitted light back to the viewer. Because in practice the CMY inks suitable for printing also reflect a little bit of color, making a deep and neutral black impossible, the K (black ink) component, usually printed last, is needed to compensate for their deficiencies. Use of a separate black ink is also economically driven when a lot of black content is expected, e.g. in text media, to reduce simultaneous use of the three colored inks. The dyes used in traditional color photographic prints and slides are much more perfectly transparent, so a K component is normally not needed or used in those media.

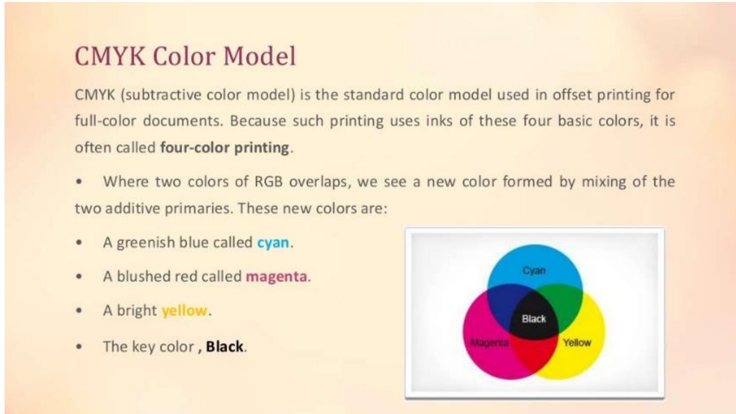

Fig 1.5: CMYK Color Model (1)

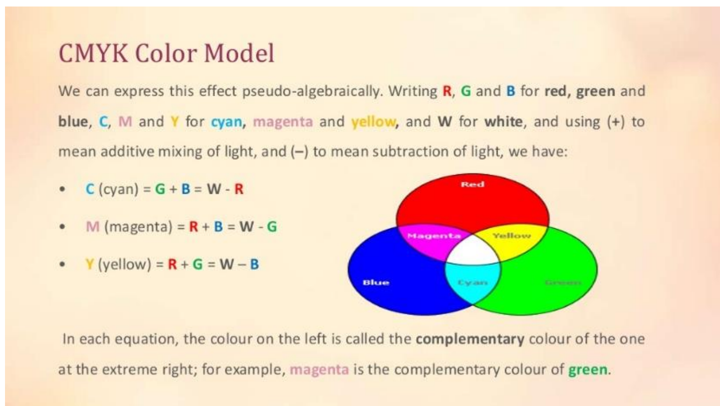

Fig 1.6: CMYK Color Model (2)

CMY uses subtractive color mixing used in the printing process, because it describes what kind of inks need to be applied so the light reflected from the substrate and through the inks produces a given color. One starts with a white substrate (canvas, page, etc.), and uses ink to subtract color from white to create an image. CMYk stores ink values for cyan, magenta, yellow, Key(Black).

cmyk(c%, m%, y%)=>(0%,0%,0%) white. [ranges from 0 to 100%]

Conversion from RGB->CMY and CMY->RGB

RGB->CMY

C = 1 - color.R / 255.0;

M = 1 - color.G / 255.0;

Y = 1 - color.B / 255.0;

CMY->RGB

R = (1 - C) * 255.0,

G = (1 - M) * 255.0,

B = (1 - Y) * 255.0

1.3 Direct Coding

Image representation is essentially the representation of pixel colors. Using we allocate a certain amount of storage space for each pixel to code its color. For example, we may allocate 3 bits for each pixel, with one bit for each primary color. This 3-bit representation allows each primary to vary independently between two intensity levels. Hence each pixel can take on one of the eight colors that corresponds to the corners of the RGB color cube.

Basically, images are the collections of several pixels with colors. In computer graphics, direct coding is an algorithm that provides some amount of storage space for each pixel so that the pixel is coded with a color.

Properties of Direct Coding:

- Storage space for each pixel to code the color
- Use 3 bytes per pixel (1 for R, 1 for G and 1 for B) [Industry standard]
- 256 different intensity level for each color

A notable special case of direct coding is the representation of black-and-white (bilevel) and gray-scale images, where the three primaries always have the same value and hence need not to be coded separately. A black-and-white image requires only one bit per pixel, with bit value 0 representing black and 1 representing white. A grayscale is typically coded with 8 bits per pixel to allow a total of 256 intensity or gray levels.

1.4 Lookup Table

In computer graphics, lookup tables are used to store the starting addresses of each line and the values corresponding to the placement of pixels within a byte. Image representation using a lookup table can be viewed as a compromise between our desire to have a lower storage requirement and our need to support a reasonably enough simultaneous color. The color of pixel is determined by the color value in the table entry that the value of the pixel references.

Steps for plot a point using a lookup table:

1. Locate the starting address corresponding to the line on which the point is to appear.

2. Locate the address of the byte in which the point will be represented.

Properties of lookup table:

- Pixel values do not code colors directly
- Refer to a table of color values
- A table with 256 colors with RGB values

1.5 Display Monitor

Among the numerous types of image representation or output devices that convert digitally represented images into visually perceivable pictures is the display or video monitor. A monochromatic display monitor consists mainly of cathode ray tube (CRT) along with related control circuits. The CRT is a vacuum glass tube with the display screen is a special material, called phosphor, which emit light for a period of time when hit by a beam of electrons. The color of the light and the time period vary from one type of phosphor to another. The light given off by the phosphor during exposure to the electron beam is known as fluorescence, the continuing glow given off after the beam is removed is known as phosphorescence and the duration of phosphorescence is known as phosphor's persistence.

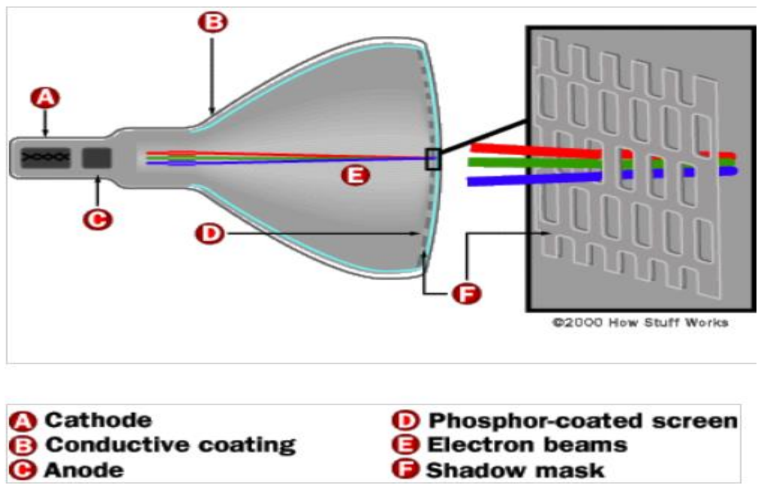

Fig 1.7: CRT Monitor

Opposite to the phosphor-colored screen is an electron gun that is heated to send out electrons. The electrons are regulated by the control electrode and forced by the focusing electrode into a narrow beam striking the phosphor coating. When this electron beam passes through the horizontal and vertical deflection plates, it is bent or deflected by the electric fields between the plates. The horizontal plate control the beam to scan from left to right and retrace from left to right. The vertical plates control the beam to go from the first scan line at the top to the last scan line at the bottom and retrace from the bottom back to the top. These actions are synchronized by the control circuits so that the electron beam strikes each and every pixel position in a scan line by the scan line function.

1.6 Printing

Another typical image presentation device is the printer. A printer deposits color pigments into a print media, changing the light reflected from the surface and making it possible for us to see the print result.

Halftoning: Halftone is a technique that stimulates continuous tone imagery through the use of dots. This technique uses variably sized pigment dots that, when viewed from a certain distance, blend with the white background to give us the sensation of varying intensity levels. Dots can be varied either:

1. In size
2. In shape
3. In spacing

Halftone generates a gradient like effect in pictures. It is composed of discrete dots rather than continuous tones. When viewed from a distance, the dots blur together, creating an illusion of continuous lines and shapes. By halftoning an image (converting it from a bitmap to a halftone), it can be printed using less resource.

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