Image Representation

Course Code: CSC 3224 Course Title: Computer Graphics

Dept. of Computer Science
Faculty of Science and Technology

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Outline

1. Pixel
2. Graphics Image
3. Color Model (RGB, CMY)
4. Direct Coding
5. Lookup Table
6. Display Monitor
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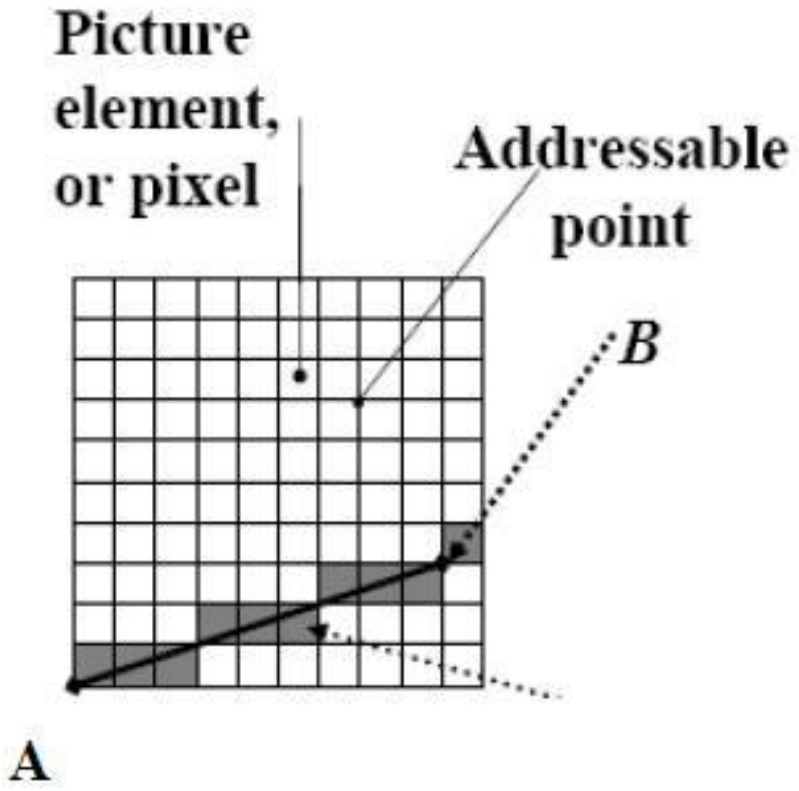
Pixel

- A pixel is one of the many tiny dots that make up the representation of a picture in a computer's memory.
- Pixels in an image can be reproduced at any size without the appearance of visible dots or squares
- The intensity of each pixel is variable; in color systems, each pixel has typically three or four dimensions of variability such as red, green and blue, or cyan, magenta, yellow and black

Pixel



Computer Graphics Image

- Computer graphics can be created as either raster or vector images

- Raster Image
- Vector Image

Raster Image

- Raster graphics are bitmaps.

- A bitmap is a grid of individual pixels that collectively compose an image.
- Raster graphics render images as a collection of countless tiny squares.
- Each square, or pixel, is coded in a specific shade. Individually, these pixels are worthless
- Together, they're worth a thousand words

Raster Image

❑ Using of Raster Image

➢Raster graphics are best used for non-line art images; specifically digitized photographs, scanned artwork or detailed graphics

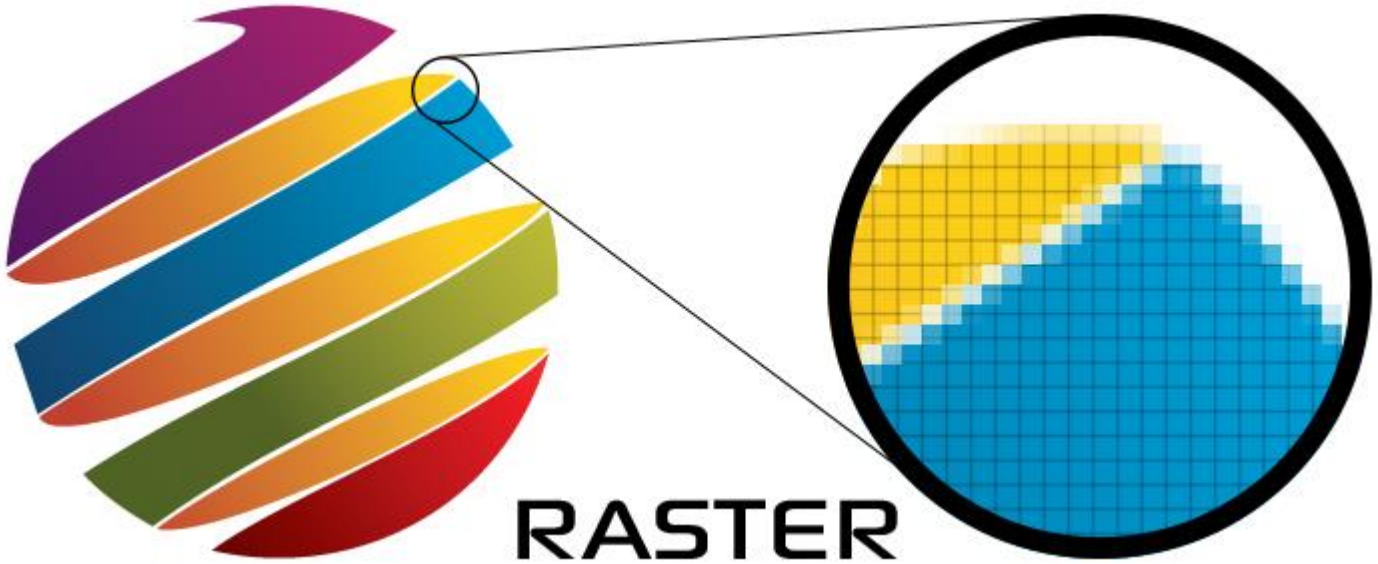
➢Non-line art images are best represented in raster form because these typically include subtle chromatic gradations, undefined lines and shapes, and complex composition

Drawbacks of Raster Image

- Resolution in raster graphics is measured in dpi, or dots per inch. The higher the dpi, the better the resolution
- Raster files are significantly larger than comparable vector files, high resolution raster files are significantly larger than low resolution raster file
- Overall, as compared to vector graphics, raster graphics are less economical, slower to display and print, less versatile and more unwieldy to work with

Example of Raster Image

- Common raster formats include TIFF, JPEG, GIF, PCX and BMP files



Vector Image

- Unlike pixel-based raster images, vector graphics are based on mathematical formulas that define geometric primitives such as polygons, lines, curves, circles and rectangles

Use of Vector Image

- Because vector graphics are composed of true geometric primitives, they are best used to represent more structured images, like line art graphics with flat, uniform colors.
- Most created images meet these specifications, including logos, letterhead, and fonts.

Advantages of Vector Image

- Vector-based graphics are more malleable than raster images
- They are much more versatile, flexible and easy to use
- The most obvious advantage of vector images over raster graphics is that vector images are quickly and perfectly scalable
- There is no upper or lower limit for sizing vector images

Advantages of Vector Image

- Unlike raster graphics, vector images are not resolution-dependent
- Vector images have no fixed intrinsic resolution, rather they display at the resolution capability of whatever output device (monitor, printer) is rendering them
- Because vector graphics need not memorize the contents of millions of tiny pixels, these files tend to be considerably smaller than their raster counterparts.

Vector Images

- Overall, vector graphics are more efficient and versatile.
- Common vector formats include AI, EPS, CGM, WMF and PICT (Mac).

Color Model

- A color model is a system for creating a full range of colors from a small set of primary colors.
- There are two types of colour models: additive and subtractive.

Additive and Subtractive Model

- Additive color models use light to display color

✓While subtractive color models use printing inks.

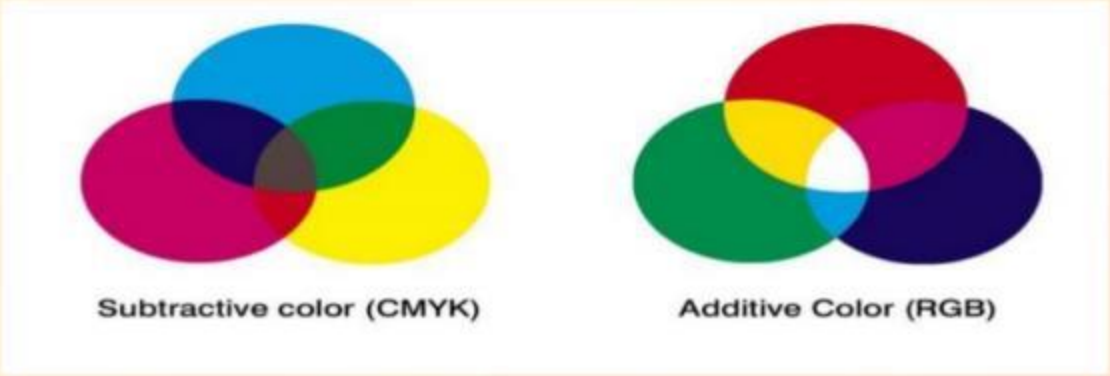
- Colors perceived in additive models are the result of transmitted light.

✓Colors perceived in subtractive models are the result of reflected light.

RGB and CMYK

Color Model

- There are several established color models used in computer graphics, but the two most common are the **RGB model** (**Red**-**Green**-**Blue**) for computer display and the **CMYK model** (**Cyan**-**Magenta**-**Yellow**-**Black**) for printing.



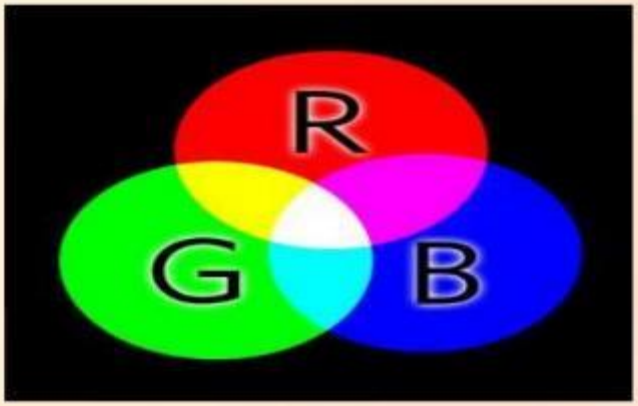
RGB

- RGB uses additive color mixing, because it describes what kind of light needs to be emitted to produce a given color.
- Light is added together to create form from out of the darkness.
- RGB stores individual values for red, green and blue.
- (r,g,b)=>(0,0,0) black, (1,1,1) white [ranges 0 to 1]

RGB

RGB Color Model

- RGB is an additive color model For computer displays **uses light** to display color , Colors result from **transmitted light**
- **Red** + **Green** + **Blue** = **White**



RGB Value

- A color's RGB value indicates its red, green, and blue intensity.
- Each intensity value is on a scale of 0 to 255

RGB Color Palette

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 **$((2^1)^3 = 2^3 = 8)$** palette

6-bit RGB

Systems with a 6-bit RGB palette use 2 bits for each of the red, green, and blue color components. This results in a $(2^2)^3 = 4^3 =$ 64-color palette

Color Palette

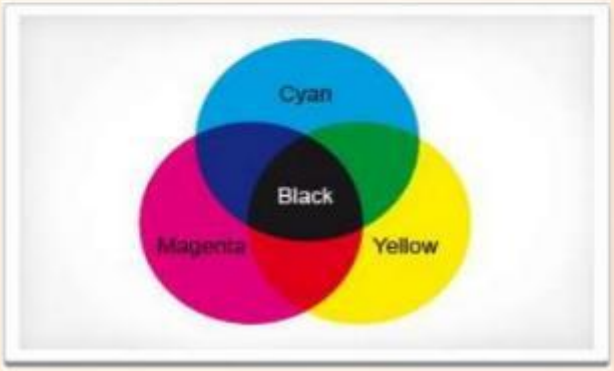
In computer graphics, a **color palette** is a finite set of colors. Palettes can be optimized to improve image accuracy in the presence of software or hardware constraints.

CMYK

CMYK Color Model

CMYK (subtractive color model) is the standard color model used in offset printing for full-color documents. Because such printing uses inks of these four basic colors, it is often called **four-color printing**.

- Where two colors of RGB overlaps, we see a new color formed by mixing of the two additive primaries. These new colors are:
- A greenish blue called **cyan**.
- A blushed red called **magenta**.
- A bright **yellow**.
- The key color , **Black**.



CMY

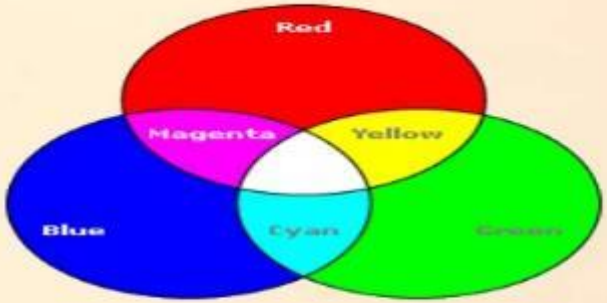
- CMY uses subtractive color mixing used in the printing process, because it describes what kind of inks need to be applied so the light reflected from the substrate and through the inks produces a given color.
- One starts with a white substrate (canvas, page, etc.), and uses ink to subtract color from 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%]

CMYK

CMYK Color Model

We can express this effect pseudo-algebraically. Writing **R**, **G** and **B** for **red, green** and **blue**, **C**, **M** and **Y** for **cyan, magenta** and **yellow**, and **W** for **white**, and using (+) to mean additive mixing of light, and (–) to mean subtraction of light, we have:

- **C** (cyan) = **G** + **B** = **W** - **R**
- **M** (magenta) = **R** + **B** = **W** - **G**
- **Y** (yellow) = **R** + **G** = **W** – **B**



In each equation, the colour on the left is called the **complementary** colour of the one at the extreme right; for example, **magenta** is the complementary colour of **green**.

RGB to CMY

- C = 1 –(color.R / 255.0);
- M = 1 – (color.G / 255.0);
- Y = 1 – (color.B / 255.0);

RGB to CMY

- R = (1 - C) * 255.0,
- G = (1 - M) * 255.0,
- B = (1 - Y) * 255.0

RGB -> CMY -> RGB

More info

http://colormine.org/convert/rgb-to-cmy

Sample Code:

https://github.com/THEjoezack/ColorMine/blob/master/ColorMine/ColorSpaces/Conversions/CmyConverter.cs

Direct Coding

- 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.

Direct Coding

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

Bit 1 R	Bit 2 G	Bit 3 B	Color Name
0	0	0	Black
0	0	1	Blue
0	1	0	Green
1	0	0	Red

Direct Coding

More info of direct coding:

https://www.chegg.com/homework-help/definitions/direct-coding-3

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.

Steps to plot a point using lookup table

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

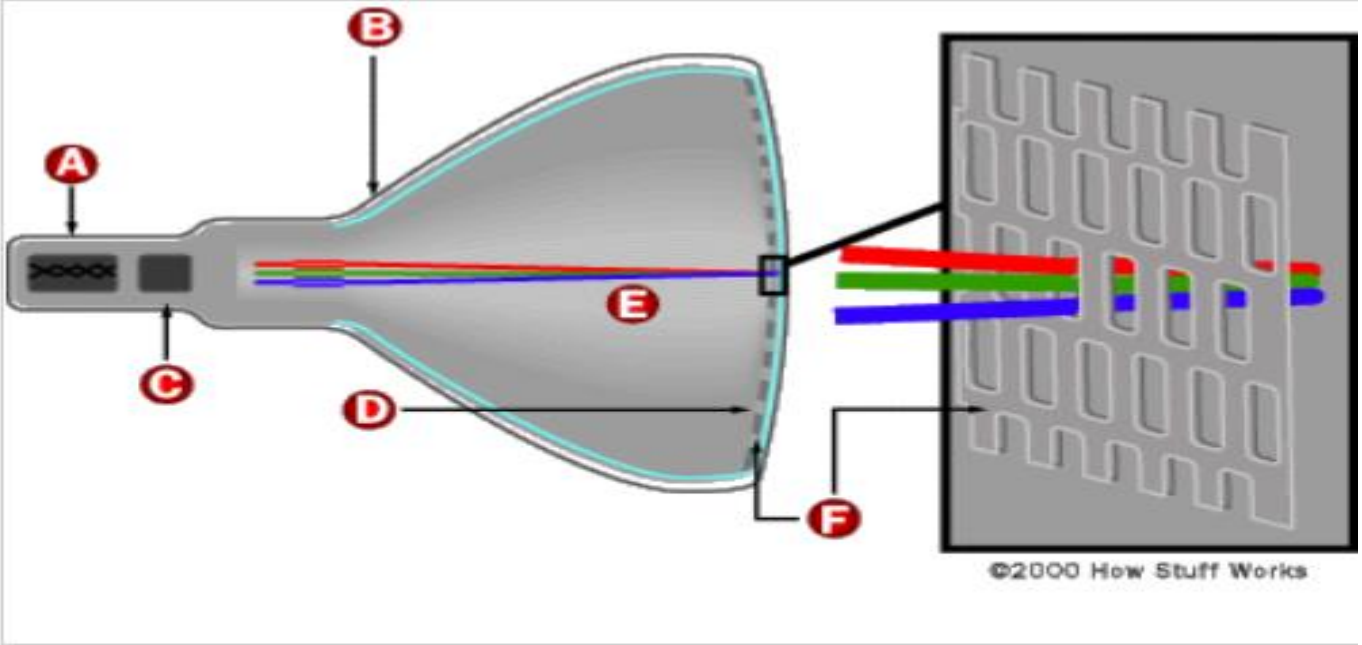
2. Locate the address of the byte in which the point will be represented.

Lookup Table

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

o	r	g	b
1	11111111	11111111	11111111
2			
255			

Display Monitor (CRT)



A Cathode	D Phosphor-coated screen
B Conductive coating	E Electron beams
C Anode	F Shadow mask

Printing

- Halftone
- Go through chapter 2 (schaum's outline) for details.

Halftone

- **Halftone** is the technique that simulates continuous tone imagery through the use of dots.
- Dots can be varied either
  - in size
  - in shape or
  - in spacing
- Halftone generates a gradient like effect.

Halftone Image

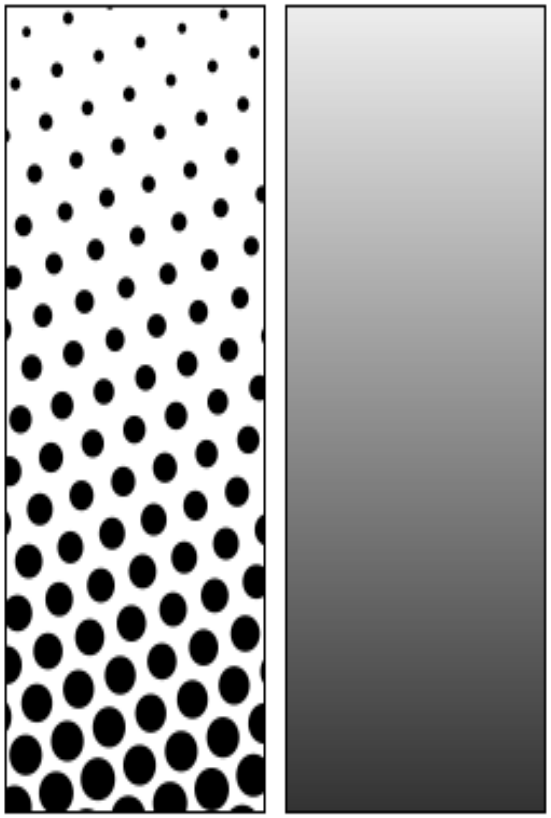
- A halftone, or halftone image, is an image comprised of discrete dots rather than continuous tones. When viewed from a distance, the dots blur together, creating the illusion of continuous lines and shapes.

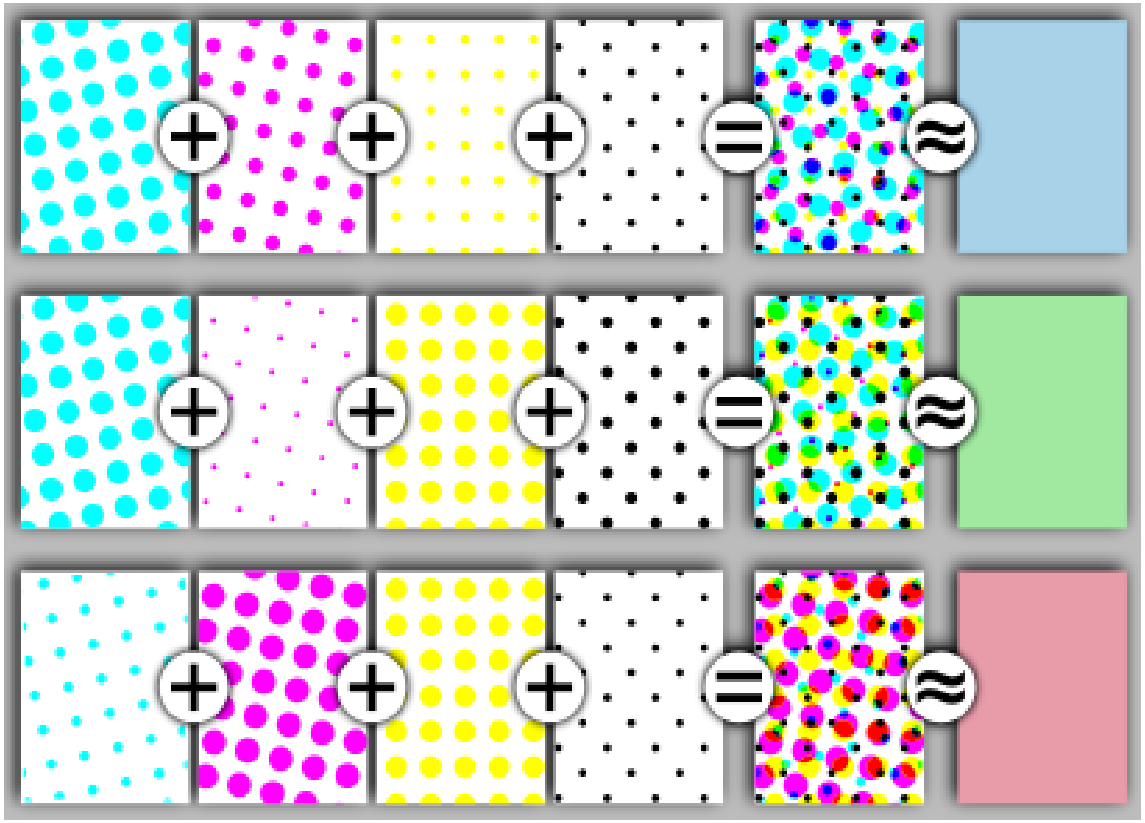
- ✓ By halftoning an image (converting it from a bitmap to a halftone), it can be printed using less resources

How Halftone work

- Halftone process, in printing, a technique of breaking up an image into a series of dots so as to reproduce the full tone range of a photograph or tone art work.

Example





Books

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- Schaum's Outline of Theory & Problems of Computer Graphics.
- Peter Shirley Steve Marschner , “Fundamental of computer graphics”, Third Edition.

References

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- https://slideplayer.com/slide/5143930/