

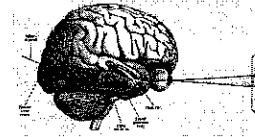
Overview

- Images
 - What is an image?
 - How are images displayed?
- Color models
 - How do we perceive colors?
 - How can we describe and represent colors?

קורס גרפיקה ממוחשבת

סמסטר ב' 2009

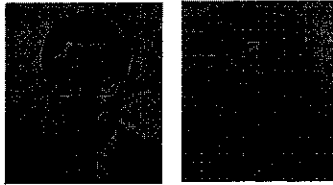
Raster Graphics



1 חלק מהשקפים מעבירים משקפים של פרדו חוראנד, טומס פנקראוסר ודניאל כהן-אור

What is an image?

- An image is a 2D rectilinear array of pixels



Continuous image

Digital Image

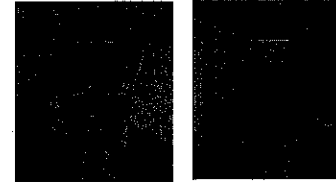
A pixel is a sample, not a little square!

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פיקסל הוא אינדיקס קואורדינטה של נקודה במרחב
והוא הקבוצה של נקודה זו במרחב זה המכילה

What is an image?

- An image is a 2D rectilinear array of pixels



Continuous image

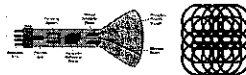
Digital Image

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Image display

- Re-create continuous function from samples
 - Example: cathode ray tube

Image is reconstructed by displaying pixels with a finite area (Gaussian)



- Example: LCD

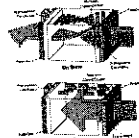
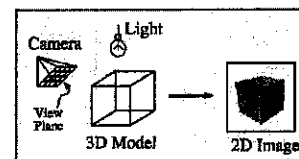


Image Acquisition

- Pixels are samples from a continuous function
 - Photoreceptors in eye
 - CCD cells in digital camera
 - Rays in virtual camera



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Image Resolution

- Intensity resolution
 - Each pixel has only "Depth" bits for color/intensities
- Spatial resolution
 - Image has only "Width" x "Height" pixels
- Temporal resolution
 - Monitor refreshes images at only "Rate" Hz

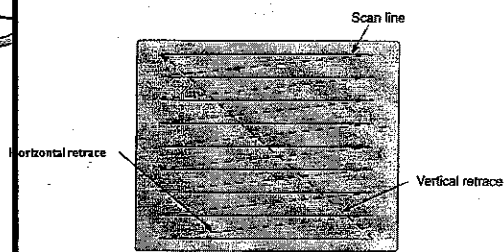
Display	Width x Height	Depth	Rate
NTSC	640 x 480	8	30
Workstation	1280 x 1024	24	75
Film	3000 x 2000	12	24
Laser Printer	6000 x 5100	1	-
Portable devices (iPod)	320 x 200	24	~75

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Display Hardware

- Video display devices
 - Cathode Ray Tube (CRT)
 - Liquid Crystal Display (LCD)
 - Plasma panels
 - Thin-film electroluminescent displays
 - Light-emitting diodes (LED)
- Hard-copy devices
 - Ink-jet printer
 - Laser printer
 - Film recorder
 - Electrostatic printer
 - Pen plotter

Frame Buffer Refresh



Refresh rate is usually 30-75Hz

Figure 1.3 from FvDFH

Frame Buffer

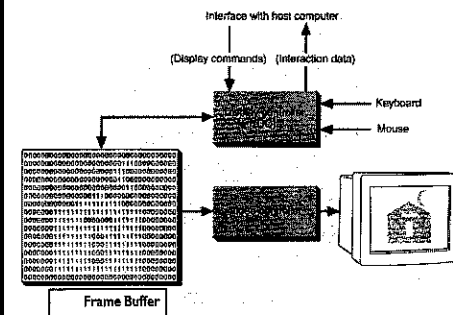
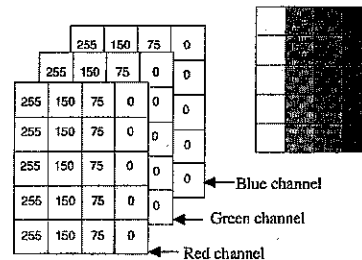


Figure 1.2 from FvDFH

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Color Frame Buffer



Figures 15.3-4 from H&B

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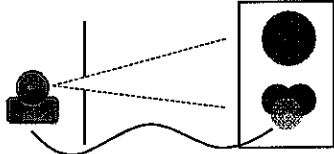
Figure 13.18 from FvDFH

Plate II.3 from FvDFH

- Linear (RGB, CMYK)
- Artistic View (Munsell, HSV, HLS)
- Standard (CIE-XYZ)
- Perceptual (Luv, Lab)
- Opponent (YIQ, YUV) – used in TV

CIE 1931 Color Space

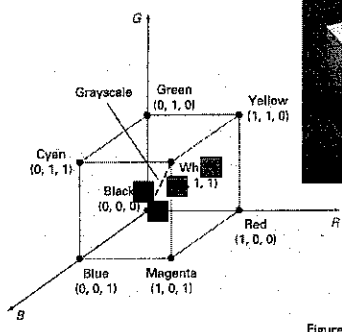
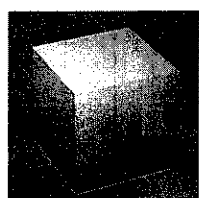
- CIE XYZ is based on experiments done by W. David Wright and John Guild in the 1920's
- It is based on direct measurements of human **visual perception**



Users could adjust brightness but not chromaticity

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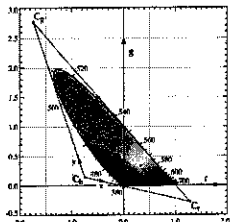
RGB Color Cube

Figures 15.11 & 15.12 from H&B

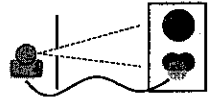
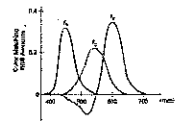
CIE 1931 Color space

- We can parameterize chromaticity by defining:

$$r = \frac{R}{R+G+B}, g = \frac{G}{R+G+B}$$


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CIE 1931 Color Space

- Experiments produced three functions: $r(\lambda)$, $g(\lambda)$, $b(\lambda)$
- Functions were normalized to have a constant area beneath them
- Therefore, RGB tristimulus values for a color $I(\lambda)$ would be:

$$R = \int_0^\infty I(\lambda) r(\lambda) d\lambda$$

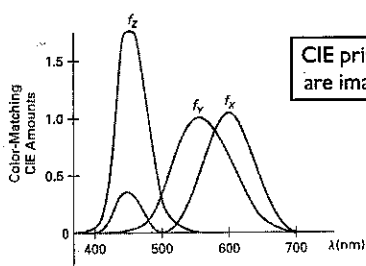
$$G = \int_0^\infty I(\lambda) g(\lambda) d\lambda$$

$$B = \int_0^\infty I(\lambda) b(\lambda) d\lambda$$

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XYZ Color Model (CIE)

Amounts of CIE primaries needed to display spectral colors

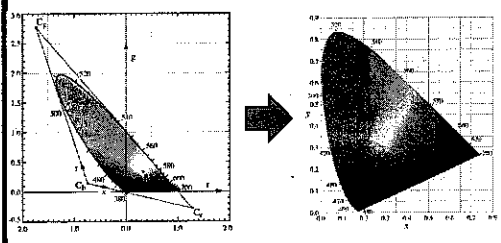


CIE primaries are imaginary

Figure 15.6 from H&B

CIE-XYZ

- Transforming the triangle to $(0,0), (0,1), (1,0)$ is a linear transformation



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