جامعة الملك عبدالله للعلوم والتقنية
King Abdullah University of Science and Technology

VCC VISUAL COMPUTING CENTER

Computer Graphics CS248

Raster Images

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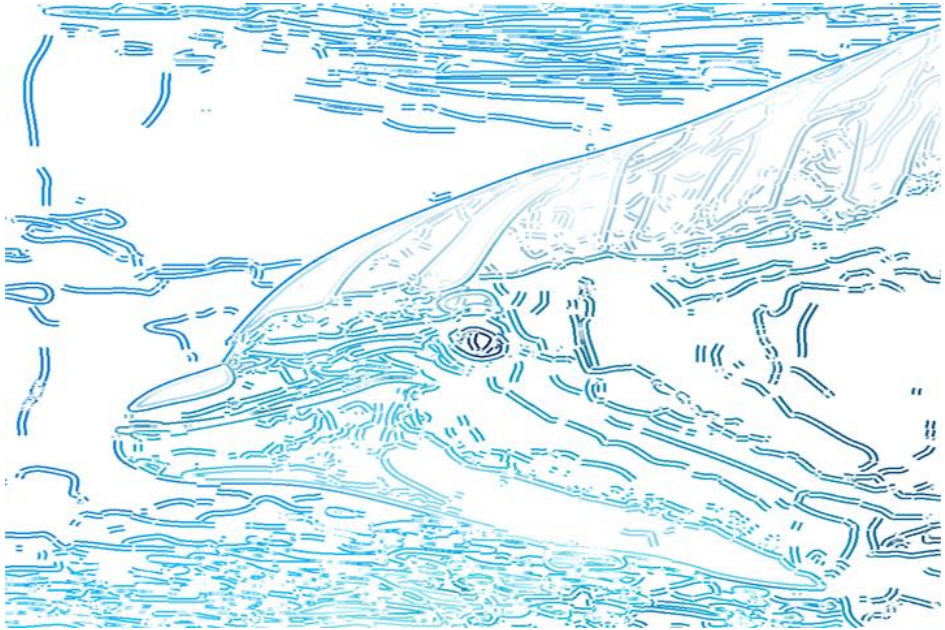
NANOVISUALIZATION GROUP

Discretized Representation: Image

- Input devices: scanners, cameras
  result in samples of the measured continuum
- Output devices: display, projector, printers
- Image is a grid of *pixels* (picture elements)
- Volume is a grid of *voxels* (volume elements)
- Resolution: (normalized) amount of samples

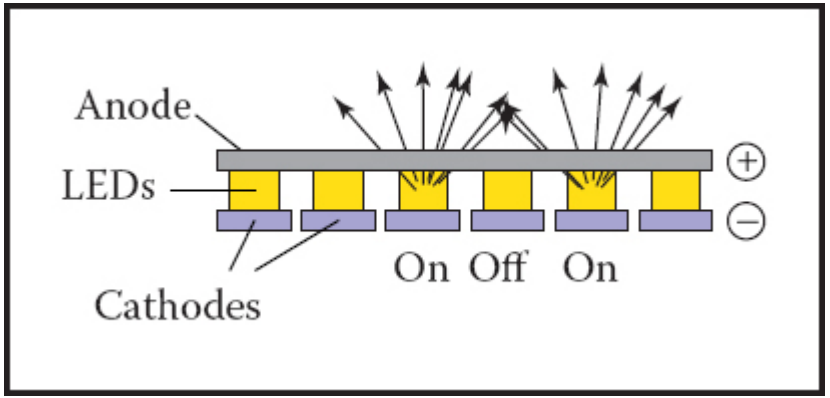
Continuous Representation: Vectors, …



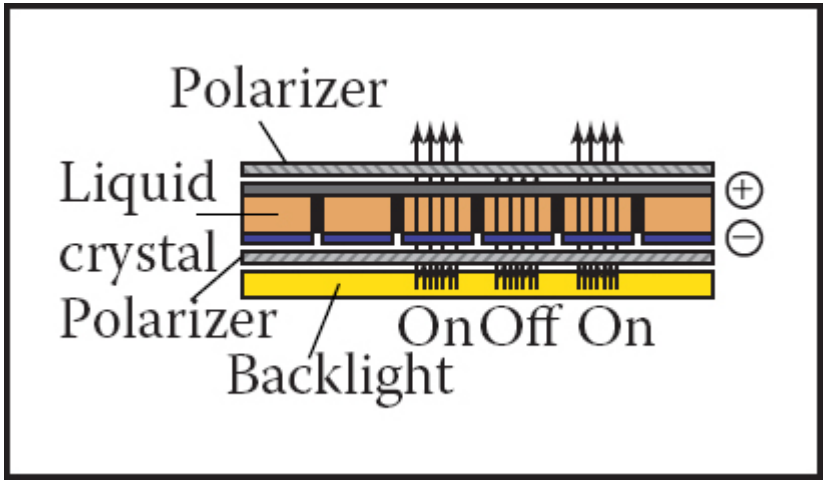
Orzan et al.: Diffusion Curves: A Vector Representation for Smooth-Shaded Images, ACM SIGGRAPH 2008

Displays

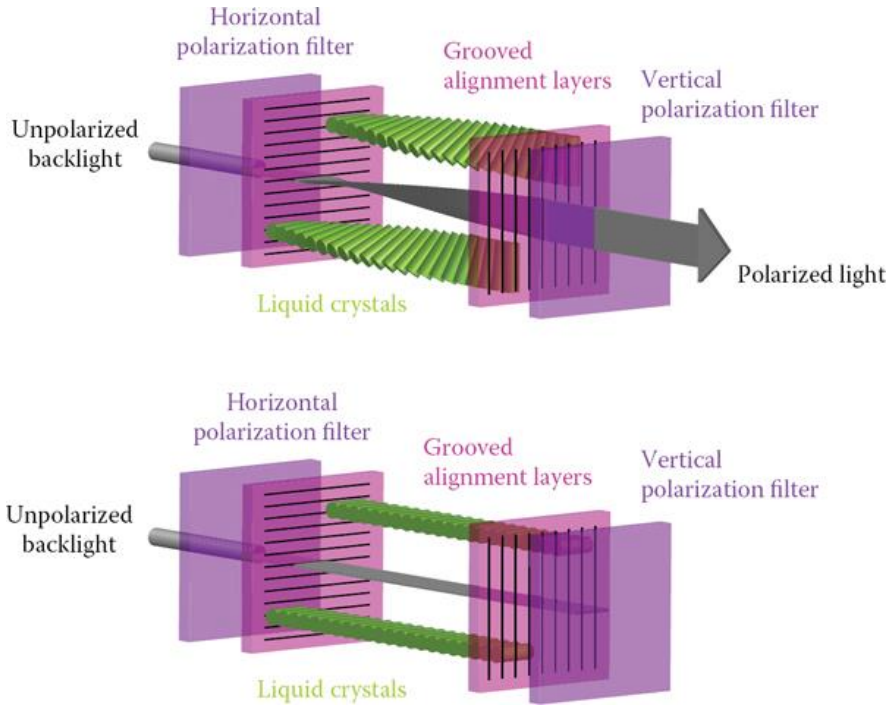
Emissive LED

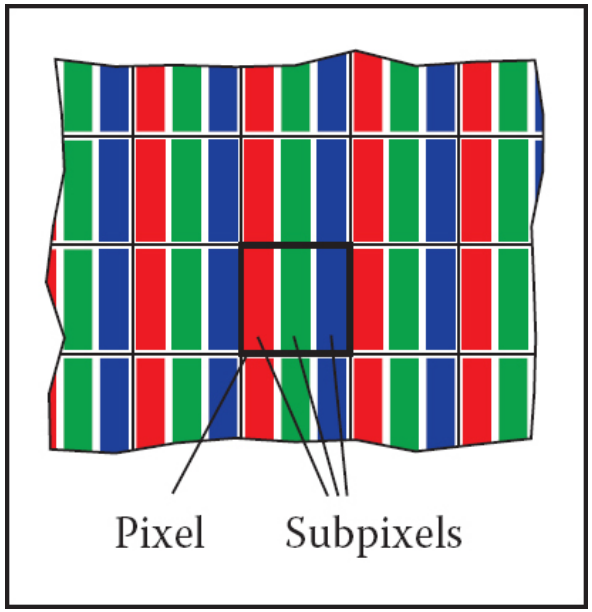


Transmissive LCD



Displays (cont.)

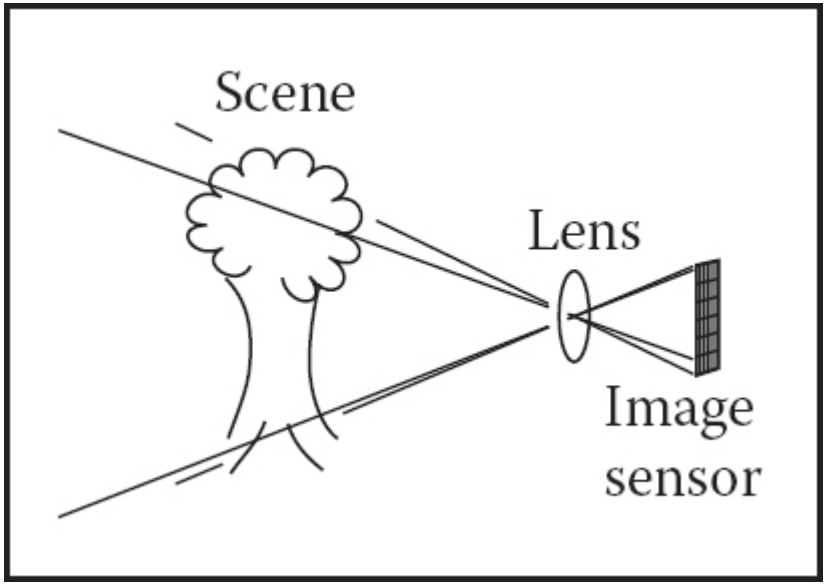


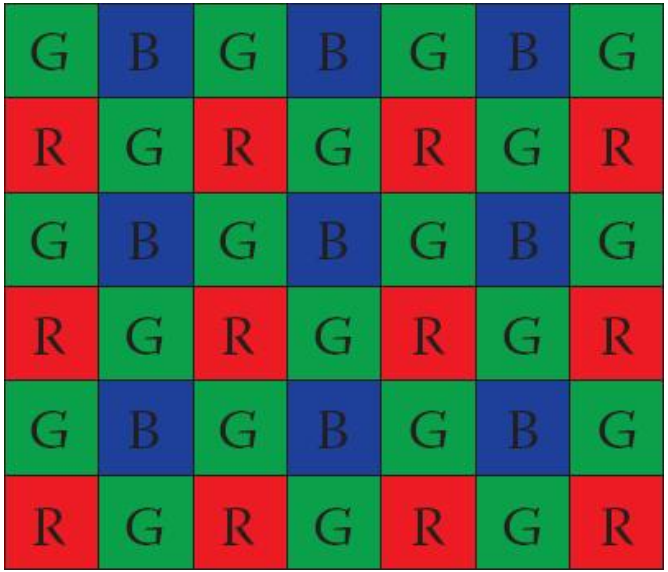


Reinhard et al.: Color Imaging: Fundamentals and Applications, CRC Press, 2008

Input Devices

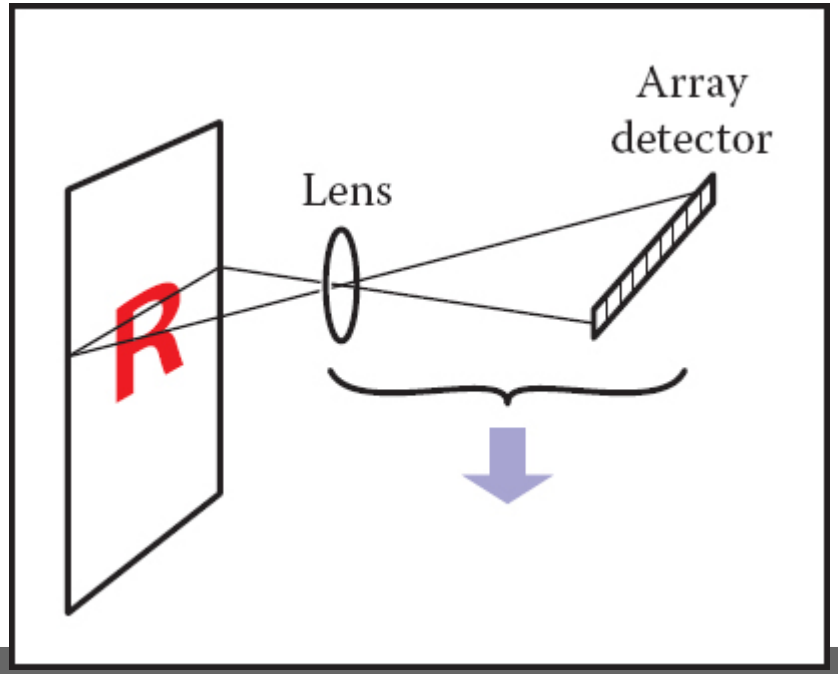
Digital camera: 2D raster input device





Input Devices (cont.)

Flatbed scanners: 1D raster input device



Formalizing Images

Definition:

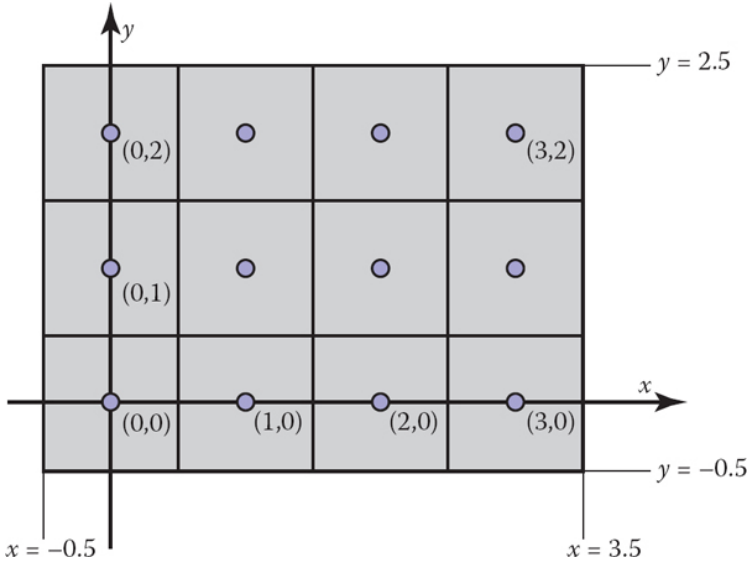
$I(x, y): R \rightarrow V$, where $R \subset \mathbb{R}^2, V \subset (\mathbb{R}^+)^3$

Indexing: (i, j) column (i), row (j)

bottom-left $\rightarrow$ top-right: $(0,0) \rightarrow (n_x - 1, n_y - 1)$

Formalizing Images (cont.)

$$\mathrm{R} = [-0.5, n_x - 0.5] \times [-0.5, n_y - 0.5]$$



Pixel Bit Depth

- Megapixel means 10^6 not 2^{20}!
- 32-bit floating point / channel in range $[0,1]$
- Low dynamic range displays 8-bit depth
  ➔ byte resolution sufficient
- High dynamic range uses 32-bit floating point

Common Formats

- 1-bit bitmap for black-and-white images
- 8-bit RGB fixed range color – LDR graphics
- 10-bit RGB fixed range color – displays
- 12-16 bit RGB fixed range – raw camera image
- 16-bit grayscale fixed range – medical imaging
- 32-bit RGB floating point – internal representation

Resolution Artifacts

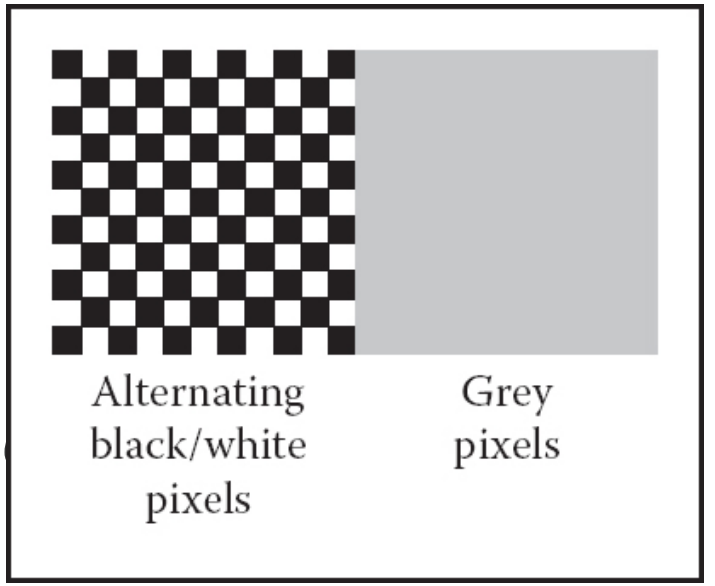
- Clipping floating point value above 1 to a fixed-range maximal value
- Quantization artifacts if the bit depth is too low resulting into banding

Monitor Intensities

- 0 value corresponds to black, 1 to while
- 0.5 halfway gray
- $I_d = I_{max} a^{\gamma}$
- Gamma estimation

$$0.5 I_{max} = I_{max}$$

- Gamma correction $a' = a^{\frac{1}{\gamma}}$



Quantization

- Continuous gradients represented by high-resolution floating-point precision of a are rounded to fixed range lower resolution
- 8-bit gives only 256 different intensity values

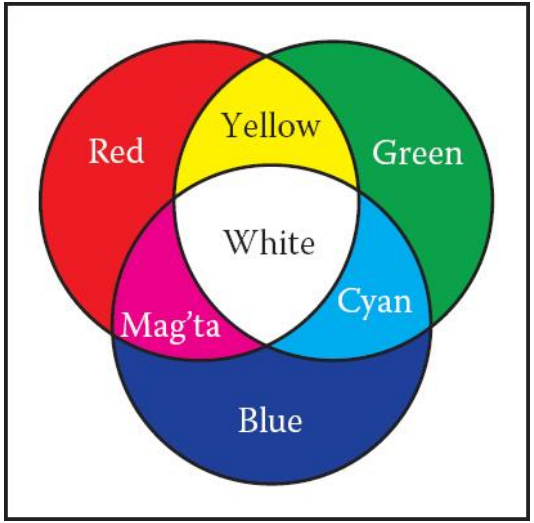
$$I_{max}\left(\frac{0}{255}\right)^{y}, I_{max}\left(\frac{1}{255}\right)^{y}, I_{max}\left(\frac{2}{255}\right)^{y}, \dots$$

RGB Color Space

- Additive Color Mixing: $W = R + G + B$

  $Y = R + G, C = B + G, M = B + R$

- Three different colors mixed with all available intensities form a 3D color space



RGB Color Space (cont.)

- RGB Space coordinates

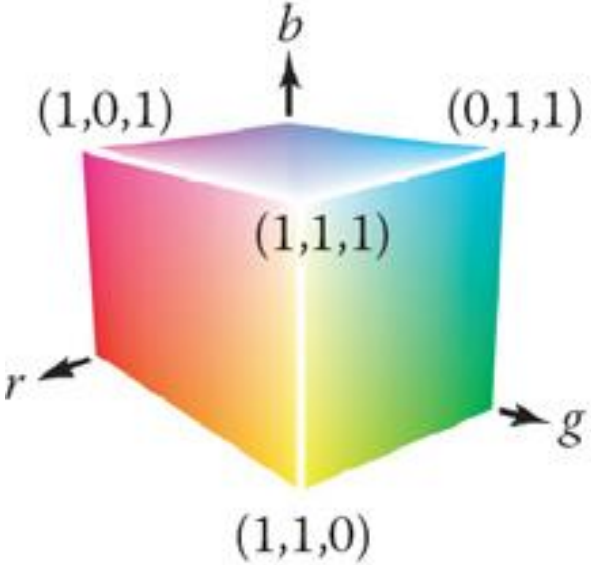
  $\mathrm{K} = (0,0,0), R = (1,0,0),$

  $\mathrm{G} = (0,1,0), \mathrm{B} = (0,0,1),$

  $\mathrm{C} = (?,?,?), \mathrm{M} = (?,?,?),$

  $\mathrm{Y} = (?,?,?), \mathrm{W} = (?,?,?)$

- $? = (0.3,0.3,0.3)$



Alpha Compositing

- $C_c = \alpha C_f + (1 - \alpha) C_b$
- Compositing a semitransparent foreground object on background
- Antialiasing for partially covered pixel area
- Alpha mask / alpha channel

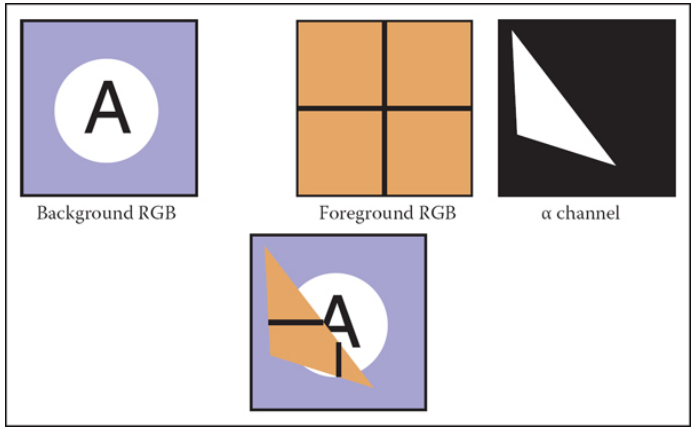
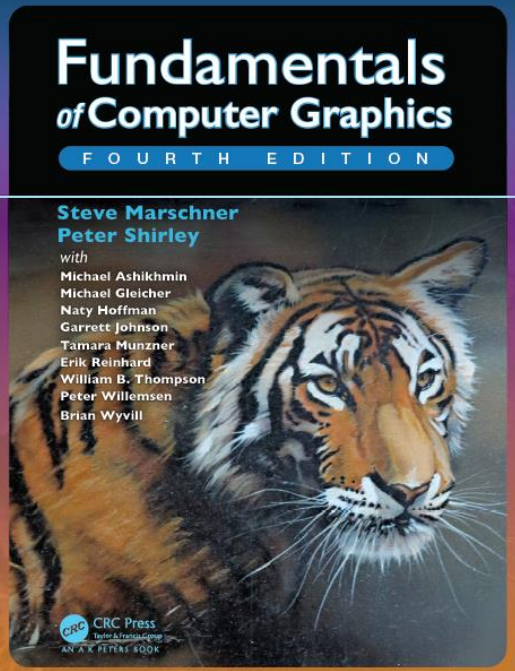


Image Formats

- Joint Photographers Expert Group (JPEG):
  perception-inspired lossy compression
- Tagged Image File Format (TIFF):
  lossless compression various formats
- Portable Pixmap (PPM):
  simple uncompressed format
- Portable Network Graphics (PNG):
  lossless compression with alpha channel

Credits



Lecture based on the Chapter 3.
Images if not otherwise stated
are taken from the book.

Fundamentals of Computer Graphics, 4th Edition
by Peter Shirley, Steve Marschner
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Available from library.kaust.edu.sa