ΟΙΚΟΝΟΜΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ

ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

Multimedia Technology

Section # 9: Still Images

Instructor: George Xylomenos

Department: Informatics

Contents

- Vision
- Digital representation
- Color encoding
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- Color depth vs resolution
- Symbolic representation
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Vision

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Vision and color (1 of 4)

- How do we perceive images?
- We start with a light source
  - Natural light, incandescent, PL, LED
- Color temperature
  - Warm white: 2000-3000K
  - Cool white: 3000-4500K
  - Daylight: 4500-6500K (sunlight ~ 5000K)

Vision and color (2 of 4)

- Each light source has a spectrum
  - Color rendering index (CRI)
  - Comparison with a reference source
    - The sun is a type B and C source
    - Incandescent lamps are type A sources
  - How close are we to the reference?
    - PL lamps generally have a low CRI
    - LED lamps generally have a high CRI

Vision and color (3 of 4)

- Light is reflected off a surface
  - The surface absorbs part of the spectrum
    - Black: absorbs the entire spectrum
    - White: reflects all the spectrum
  - The leftover also depends on the source
    - Assume a monochromatic source (e.g., red laser)
    - Only red can be reflected!
  - Reflection depends on source and surface

Vision and color (4 of 4)

- The reflected light reaches our eyes
  - The eye can send intensity and color
    - Different sensors for each color (RGB)
    - Separate sensor for low intensity
  - The eye has a complex behavior
    - Less sensitive to blue, more sensitive to green
    - Combines intensity and color

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Digital representation

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Image representation (1 of 3)

- Image: representation of a scene
  - Projected into a plane (2D)
  - Continuous function (any value at any point)
  - Natural or synthetic image
- Image digitization
  - Rectangular sampling grid: resolution
  - Quantization to discrete values: color depth
  - Storage in an array: picture elements (pixels)

Image representation (2 of 3)

- Example: VGA
  - 640x480 pixels (lines x columns)
  - 8 bits per pixel or bpp (256 colors or intensities)
- Capture formats
  - Simple representation
  - Quick capture and presentation
- Storage formats
  - Efficient storage
  - Flexible management

Image representation (3 of 3)

- Representing pixel color
  - Three intensities (RGB)
  - Three pointers to intensities
  - Pointers to RGB triples (CLUT)
  - Or, a linear transform to another space
- Image metadata
  - Height, width, color depth
  - Usually in storage format header

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Color encoding

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Color representation (1 of 4)

- Grayscale images: only intensities
- Color images: color and intensity
- Red, Green, Blue encoding (RGB)
  - Additive representation
  - Combines three light sources
  - Corresponds to the way we see
- Color depth: 24 bits
  - White: 255*R+255*G+255*B
  - Black: 0*R+0*G+0*B

Color representation (2 of 4)

- Color space transforms
  - Linear 3x3 transforms to/from RGB
  - Produce a different color representation
  - We choose one based on the application
- Basic colors
  - A set where none is produced by the others
  - Three basic colors are enough to create all
  - RGB is one example

Color representation (3 of 4)

- CMY/CMYK encoding
  - Light absorption instead of production
  - Subtractive coding
  - Used in printing
  - Basic colors: Cyan, Magenta, Yellow (CMY)
  - Black: all colors
  - White: no colors (in white paper!)
  - Black (K) added for economy

Color representation (4 of 4)

- Luminance/Hue/Saturation encoding
  - Luminance: white to black
  - Hue: red to purple
  - Saturation: white to pure color
  - Used in drawing/painting programs
- Luminance/chrominance encodings
  - YUV and YIQ: see video chapter
  - Used for more efficient transmission
    - Also, backwards compatible with BW TVs!

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Imaging devices

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Input devices

- Drawing devices
  - Mouse
  - Graphic tablet
  - Touch screen
    - Using fingers or stylus
- Capture devices
  - Scanner
  - Still camera

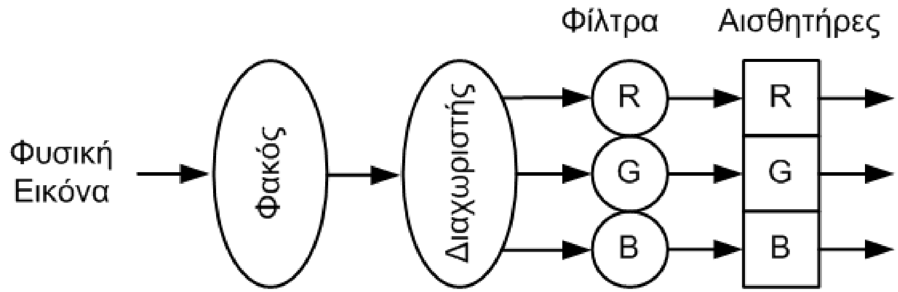
Scanner

- Used to capture printed images
  - Scans the image in one direction
    - Moving either the image or the scanning head
  - Scanning head
    - Produces very intense light
    - The light is reflected on the cover
      - Or the printed surface
    - A sensor detects the reflection

Still camera (1 of 2)

- Used to capture natural images
  - Light comes through a lens
  - Detected by a CCD (or CMOS) sensor
    - In the past the CCD scanned the image
    - Now the CCD can cover the entire image
- How does it detect color?
  - CCDs just detect light intensity
  - Colors must be separated

Still camera (2 of 2)

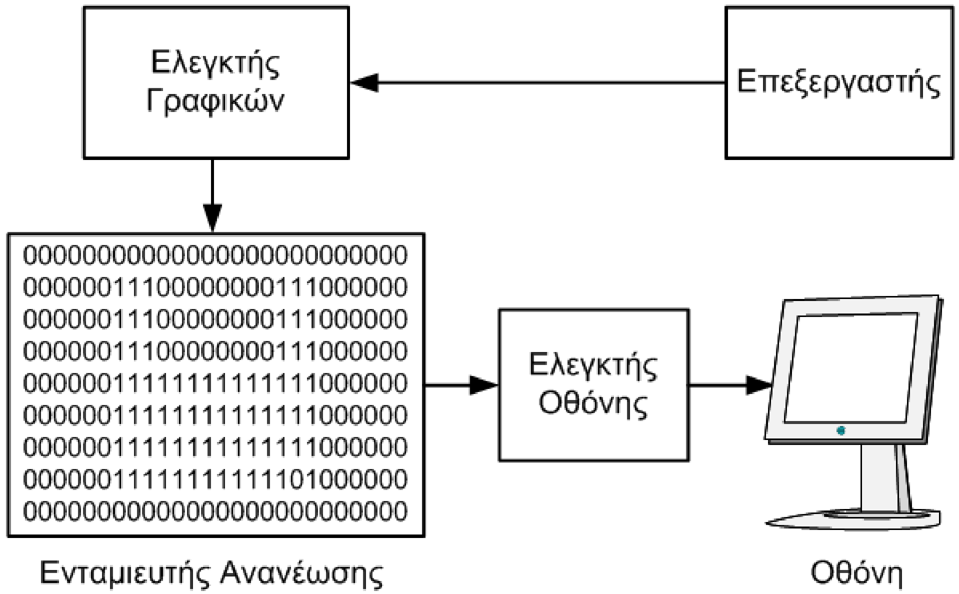


- Filtering mask
  - Only a single color reaches each CCD
  - For CCD elements per pixel
    - Two green, one red, one blue
- Separation prisms
  - Each color reaches a separate CCD array

Output devices

- Screen, printer, plotter
  - Raster devices
    - Print an array of (possibly, colored) dots
    - Nearly every screen and printer
  - Vector devices
    - Print actual lines
    - Plotters
    - Older screens

Screens (1 of 5)



- Screen output requires multiple elements
  - Graphics controller
  - Refresh buffer
  - Display controller

Screens (2 of 5)

- Graphics controller
  - Draws images to a refresh buffer
  - Many ways to achieve this
- Refresh buffer
  - Dual ported memory
  - Mediates between the controllers
- Display controller
  - Converts the buffer to screen commands

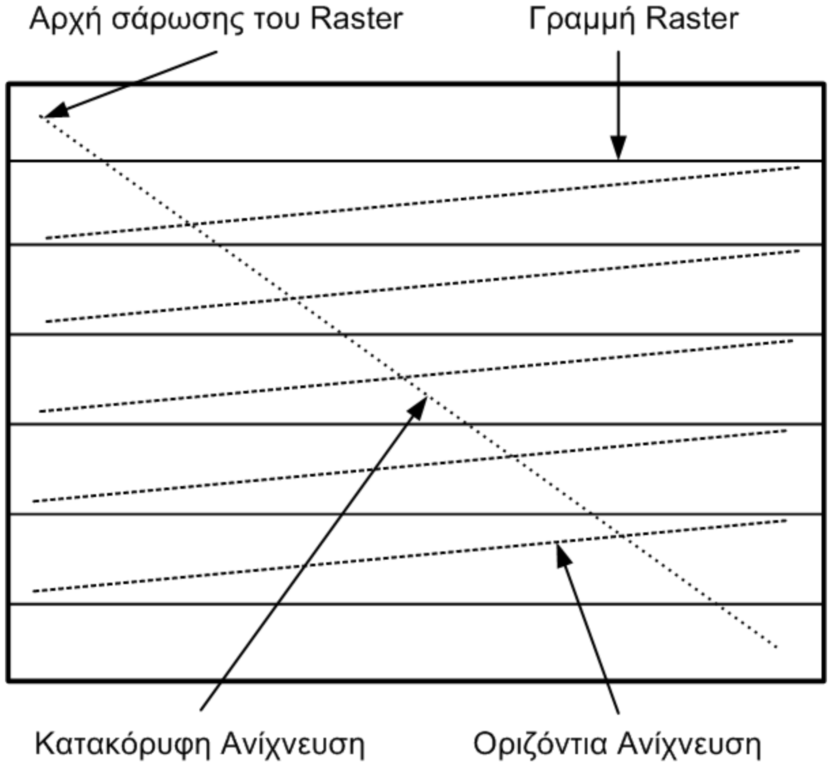
Screens (3 of 5)

- What is in the refresh buffer?
- In the past, character codes (MDA)
  - The processor writes the codes
  - The controller converts them to pixels
    - Uses a ROM with the character glyphs
- Alternatively, tile codes
  - The processor writes tile codes
  - The controller converts them to pixels
    - Uses a ROM or RAM with the tile images

Screens (4 of 5)

- Now, just pixels!
  - The graphics controller draws to memory
    - Based on CPU commands
    - May perform quite complex operations
    - Shading, projection, mapping
  - The memory holds a pixel array
    - At the appropriate resolution and color depth
  - The display controller reads the memory
    - And drives an interface to the screen

Screens (5 of 5)



- Pixel rendering order
  - CRT screens need retrace intervals

Screen types (1 of 4)

- Cathode ray tubes (CRT)
  – An electron gun scans the screen line by line
  – It bombards phosphor elements on the screen
    - Different color elements in color screens
- Screen refresh for CRTs
  – The phosphors get discharged
  – We need to refresh (redraw) each line
  – Refresh rate given in Hz (e.g., 50 or 60 Hz)

Screen types (2 of 4)

- Horizontal and vertical retrace
  - Moving the electron gun to next/first line
  - Can be used to transfer metadata
- Liquid Crystal Displays (LCD)
  - Each pixel is and independent devices
  - Liquid crystal and polarizer
  - Blocks or allows light to pass through
  - Filters used for color displays

Screen types (3 of 4)

- Liquid Crystal Displays (LCD)
  - The pixels do not actually produce light
    - They either reflect ambient light
    - Or backlighting is used (PL or LED)
  - The image does not need refreshing
    - The liquid crystals stay in the same state
    - Only need to read the buffer to change the image
    - Normally, line by line as in CRTs

Screen types (4 of 4)

- Organic LED displays (OLED)
  - Each pixel produces its own light
  - No need for backlighting
    - Higher intensity with less energy
    - Pixels can be burnt with constant use
  - Otherwise, the same as LCDs
    - No need to refresh the image
    - Only need to redraw it

Printers (1 of 2)

- Printers use subtractive synthesis
  - Colors on the page absorb the light
- Dot matrix printers
  - A head presses an ink ribbon on the paper
- Inkjet printers
  - A head sprays color on the paper
- Laser, LED, dye sublimation, etc.

Printers (2 of 2)

- Page description languages
  - Decouple image from output
  - Description of objects (lines, letters)
  - The printer translates them to a raster
    - Essentially, draws the page in memory
  - Adobe PostScript, HP PCL
  - Used (far less, though) for screen description

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Color depth vs resolution

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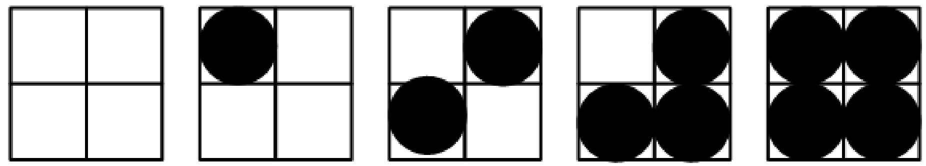
Dithering (1 of 3)

- The available colors are not infinite
  - Printing uses at most four colors (CMYK)
  - Can we avoid mixing them?
    - To prevent soaking the page
- Half toning
  - Prints dots of different sizes
    - Printed next to each other
    - Size depends on intensity
  - Used in large scale printing (banners)

Dithering (2 of 3)

- Dithering
  - Half toning for pixels
    - Pixels have the same size!
  - Based on color mixing by our eyes
  - Simulates larger color depth
    - Sacrifices resolution for color
  - Based on pixel patterns
    - Simulation of additional gray scales
    - Simulation of additional colors

Dithering (3 of 3)



- Example: 2x2 pattern
  - Loses half of the resolution in each dimension
    - One quarter of the original
  - 5 instead 2 of 2 levels
    - As long as we are far enough from the pixels
  - In general: k pixels for k+1 gradations
    - More interesting with color

Antialiasing (1 of 2)

- Pixelization: visible pixel artefacts
  - Curves
  - Diagonal lines
  - Characters in small sizes
- Anti-aliasing
  - Simulates partially covered pixels
  - Makes lines seem smoother
  - Avoids lines with dissimilar width

Antialiasing (2 of 2)

- Improves perceived resolution
  - Intensity depending on pixel coverage
  - Intermediate colors at edge pixels
  - Used (a lot!) for text
    - Example: the vertical lines in N
    - At small sizes, they may no have the same width
    - We draw some pixels in gray
  - Sacrifices color depth for resolution

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Symbolic representation

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Graphics (1 of 5)

- Basic elements of computer graphics
  - Various shapes
    - Example: circle
  - Attributes of shapes
    - Example: center, diameter, line width
- Graphics library: a collection of elements
  - Defines shapes and their attributes
  - Can be standardized at different levels
    - Closer or further from hardware

Graphics (2 of 5)

- Symbolic representation of images
  - Reduction of storage requirements
  - Easier modification (e.g., move a circle)
  - Needs conversion before output
  - Conversion depends on output device
- Special graphics hardware
  - Line draw, fills, texture mapping
  - Use software when not available

Graphics (3 of 5)

- Graphics combine 4 subsystems
- Application model
  - – Basic shape definitions
    - What shapes are available
    - What properties can be defined
  - – Independent of hardware and OS
  - – Example: Adobe Illustrator files (.ai)

Graphics (4 of 5)

- Application program
  - Handles user input
  - Applies input to application model
  - Sends commands to graphics system
  - Example: Adobe Illustrator app
- Model vs. app
  - Many apps can handle .ai files
  - But each one of them works differently

Graphics (5 of 5)

- Graphics system
  - Elementary graphics commands
  - Standardized library (independent of apps)
  - Example: OpenGL, DirectX
- Graphics hardware (controller)
  - Pixel drawing commands
  - Optimization of some graphics commands
  - Example: AMD RX470

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Image transmission

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Transmission (1 of 3)

- What do we need to transmit an image?
  - Size depends on format
    - Resolution & color depth
    - Raw, compressed, symbolic
  - In general, no real time requirements
    - Image appears whenever it arrives!
  - Requirements at receiving end also vary
    - Depending on format

Transmission (2 of 3)

- Transmission of raw image
  - Uses a capture format
  - More data, less or no processing
- Transmission of compressed image
  - Storage format
  - Requires decompression
- Transmission of symbolic image
  - Graphics format
  - Requires transformation to output

Transmission (3 of 3)

- Transmission reliability
  - Unimportant for raw images
    - May have a few corrupted pixels
  - Important for graphics
    - May corrupt entire shapes
  - Very important for compressed images
    - Small losses can make the image unreadable
    - The price or removing redundancy!

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End of Section # 9

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