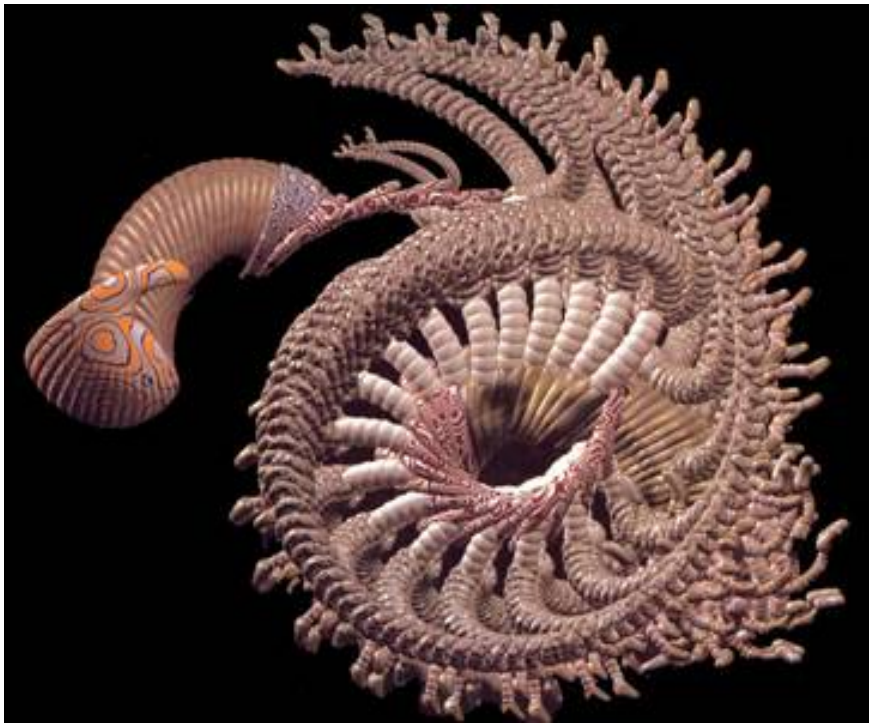
Raster Images and Displays

Outline

- Overview
- Example Applications

What is an image?



An image is

For our purposes, an image is:

- A 2D distribution of gray levels or intensity, colors, or opacities
- A function defined on a 2D plane with samples at regular points (almost always a rectilinear grid)

To do graphics, we must:

- **Represent images** – encode them numerically
- **Display images** – realize them as actual intensity distributions

Operating principle: humans are trichromatic

- Match any color with blend of 3

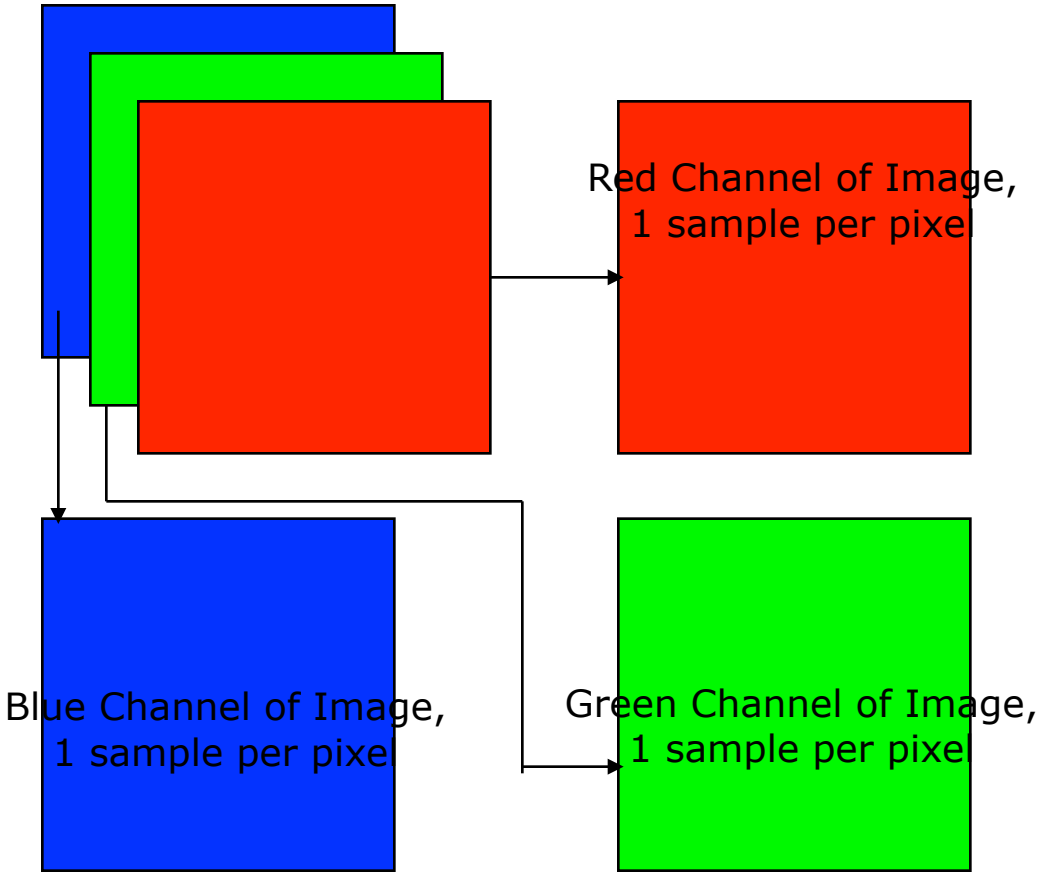
Represent images

Represent images

Common image types include:

- 1 sample per point (B&W or Grayscale)
- 3 samples per point (Red, Green, Blue)
- 4 samples per point (Red, Green, Blue, and "Alpha", a.k.a. Opacity)
- 5 samples per point (add "Depth")

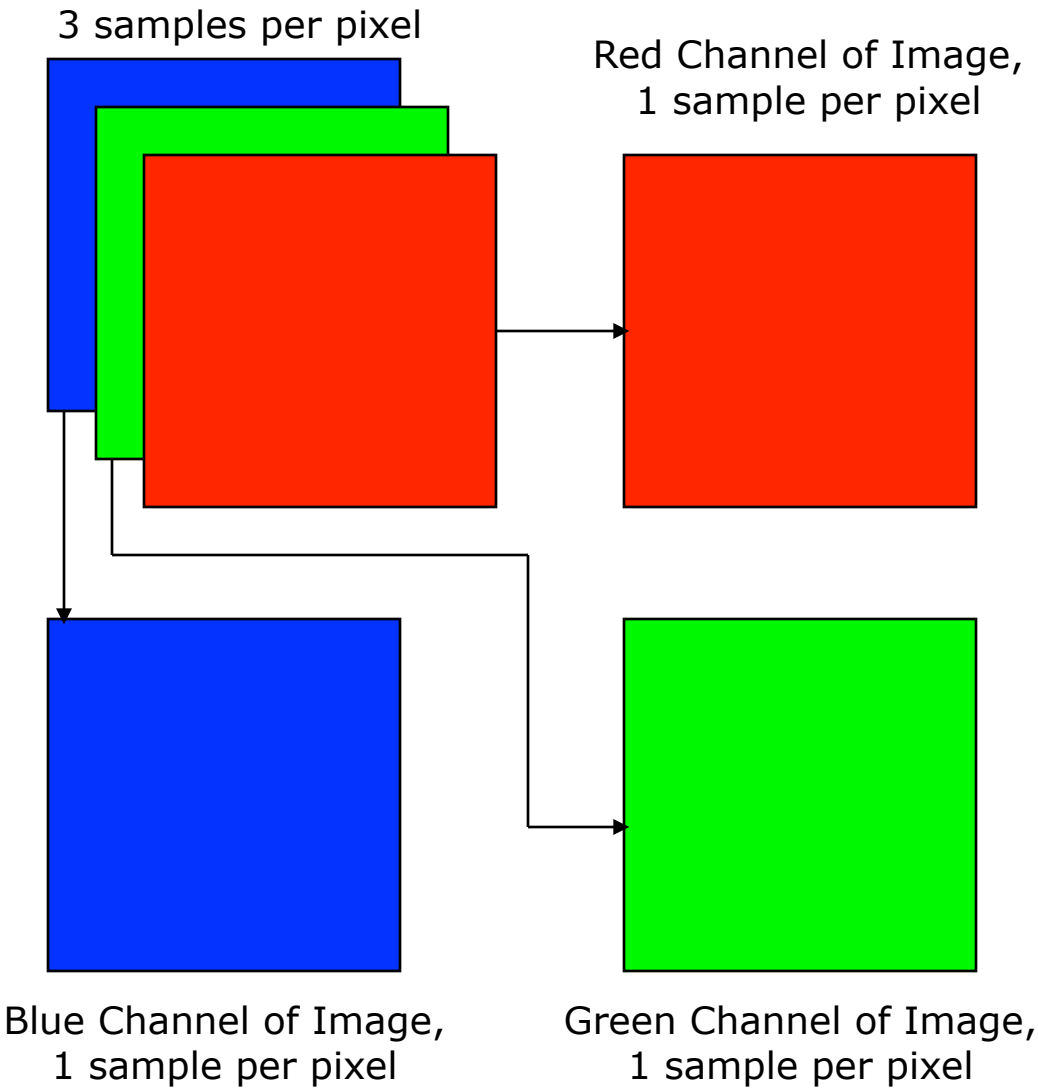
3 samples per pixel, *RGB makes good primaries*



Channels

Each of these planes is a "channel".

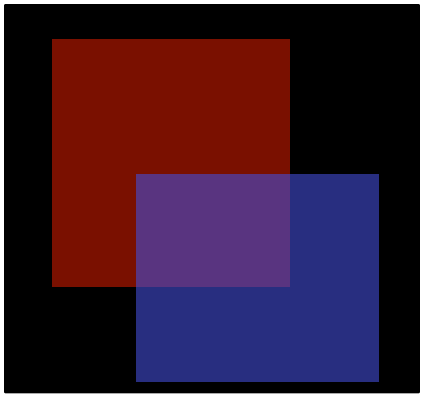
The red channel of a 3 sample per pixel image is a 1 sample per pixel image, consisting of just the red values from the original image.



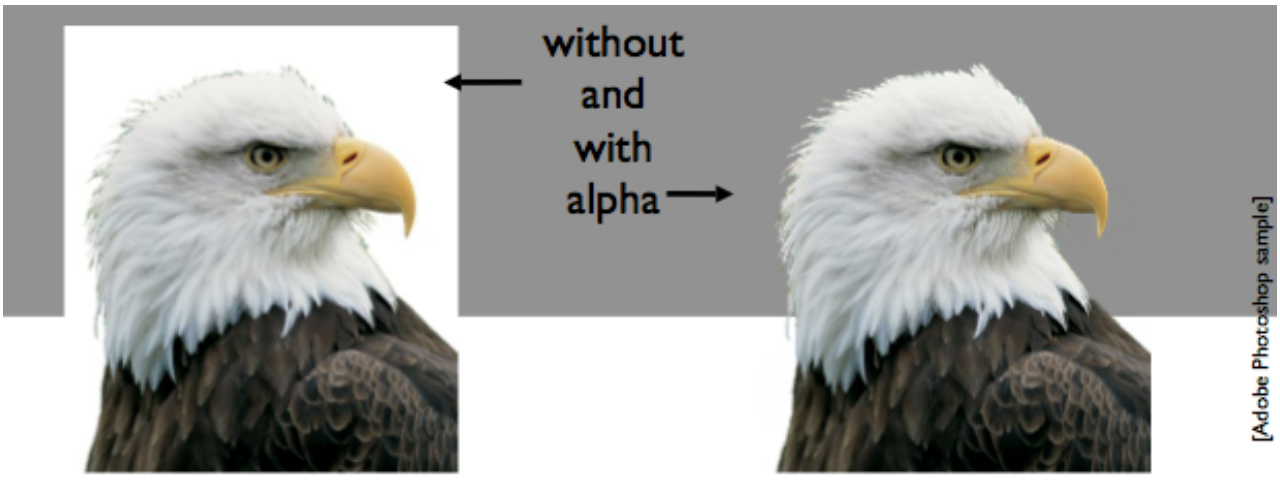
The Alpha Channel

Adding opacity information to pixels

- In addition to R, G, B channels of an image, add a fourth channel, called α
- Alpha: [0, 1]
- Useful for blending images
  - image with higher alpha value "shows through" more



(Both squares have α=0.6)



Display images

Representative display technologies

Computer Displays

- Raster CRT display
- LCD display

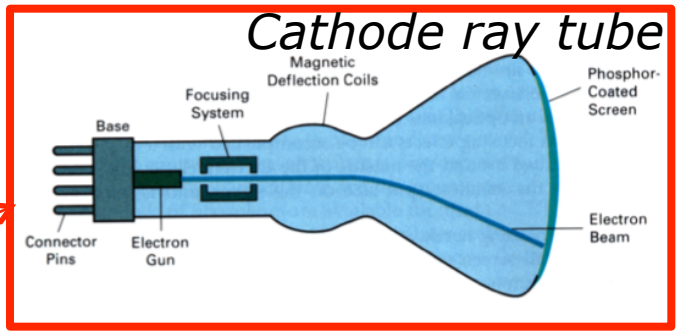
Printers

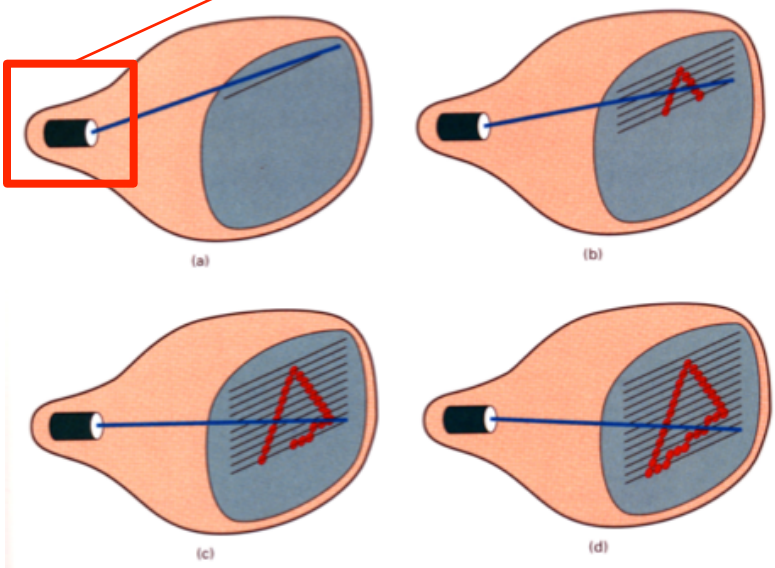
- Laser printer
- Inkjet printer

Representative display technologies

Computer Displays

- Raster CRT display
- LCD display



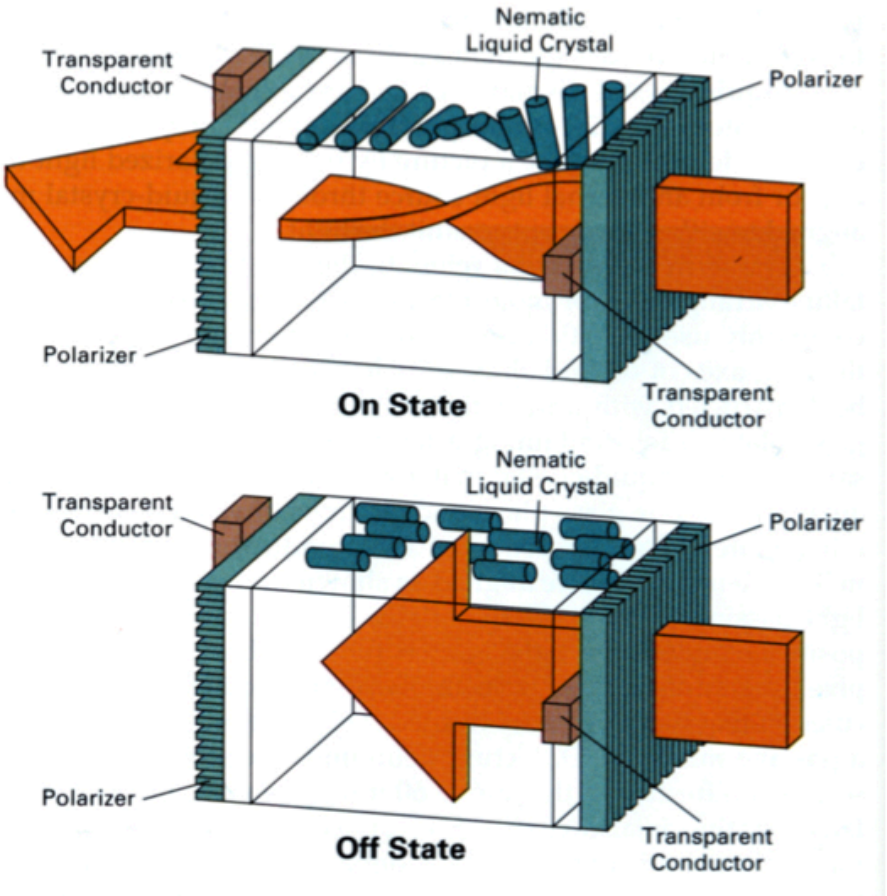


[H&B fig. 2-7]

Representative display technologies

Computer Displays

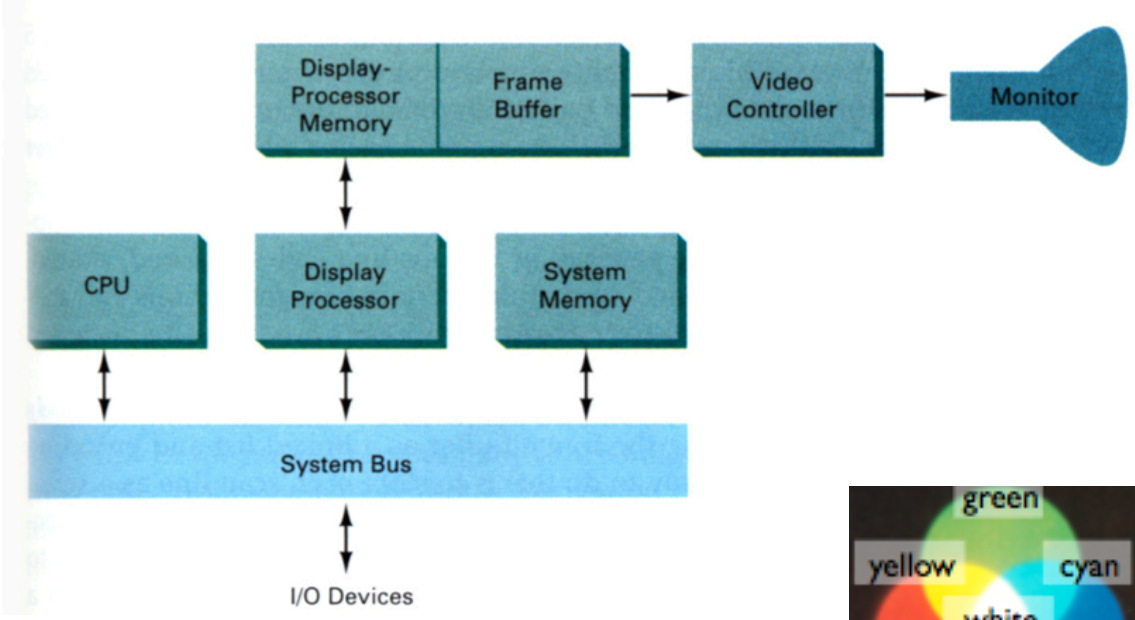
- Raster CRT display
- LCD display



[H&B fig. 2-16]

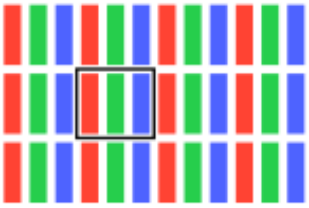
Raster display system

- Screen image defined by a 2D array in RAM
- The memory area that maps to the screen is called the *frame buffer.*



- CRT: dot pattern to produce finely interleaved color images

- LCD: interleaved RGB pixels.



But want to display images that do not fit the hardware (e.g., too big?)

Example Applications

Examples

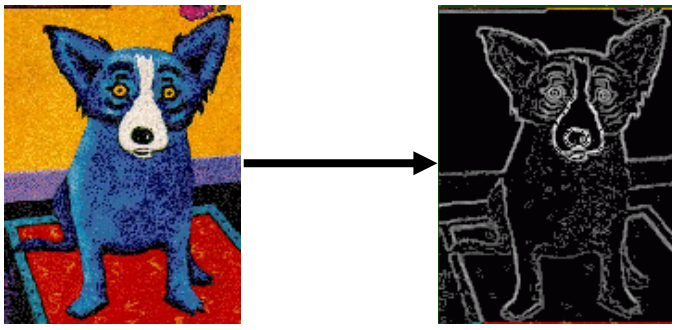
Give an idea of what is done with image processing

- Image enhancement
  - scientific filtering
  - forensic science
- Multipart composition
- Computer vision

An Application of the Edge-Detection Filtering Technique

Some filtering techniques are designed to make features in an image more apparent

- Done by using a filter that accentuates changes above certain threshold
- Make specific features of an image stand out
- Can even calculate a new image based on some function that takes an image to another image
- e.g., define an image by the magnitude of change in the original image at each point.
  - Thus, higher-valued pixels in new image are places where original image was changing rapidly

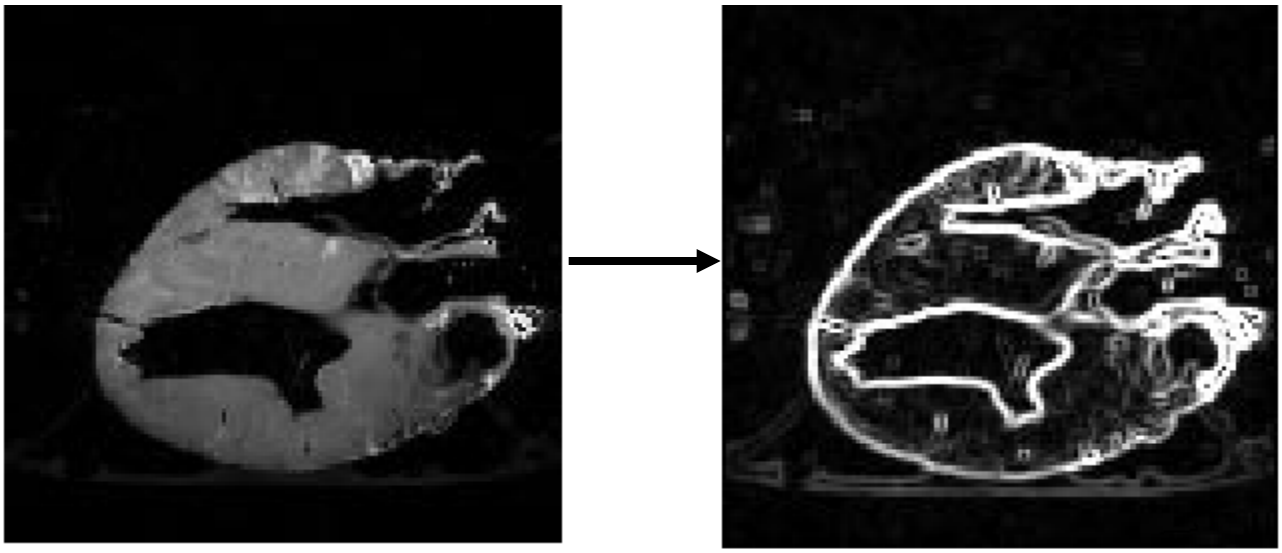


Just an illustration, not an MRI: see the next slide

MRI Image Enhancement

Take slice from MRI scan of canine heart, and find boundaries between types of tissue

- Image with gray levels representing tissue density
- Using filter from previous slide, compute new image. Again, new image brighter where MRI image gray values changing faster
- Different densities of different types of matter will show up with bright boundaries in between.



Original MRI Image of a Dog Heart

Edge Detection Image

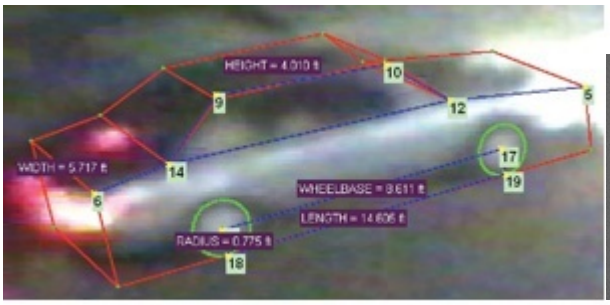
Forensic Science Image Enhancement

Image enhancement has been used by forensic scientists for years to pull information from seemingly hopeless images.

- We have a security camera video of the back of a car that was used in a robbery
- The image is too dark and noisy for the police to pull a license number

Image processing like this in the media a lot in the last few years

- These techniques have been used to find small features in satellite images
- Image processing for forensic science is even spotlighted in popular entertainment, such as the TV show CSI: Crime Scene Investigation



Multipart Composition

Image composition is popular in art world, as well as in tabloid news

- Takes parts of several images and creates single image. Hard part is making all images fit together naturally
- Artists can use it to create amazing collages and multi-layered effects
- Tabloid newspaper artists can use it to create “News Photos” of things that never happened

Multipart Composition

- Some famous examples of faked photos include:

Reuters photo of Beirut

Chinese press photo of Tibet railway

Tom Hanks and JFK

Computer Vision (1/2)

Image enhancement also done to enhance images for computer vision

- Computer must do all processing, without human intervention
- Processing techniques must be fast. If slow, will add to camera-to-reaction lag (latency) in system
- Common preprocessing techniques for computer vision include edge enhancement, region detection, contrast enhancement, etc..
- Computer must do more than enhance an image before reacting to it. Must pull specific information from image, such as position and orientation of edges

Computer Vision (2/2)

Image enhancement can also be done to enhance images for computer vision

- Image processing makes information easier to find
- Pattern detection and pattern recognition are separate fields in their own right
  - Pattern detection: looking for features and describing the image's content at a higher level
  - Pattern recognition: classifying collections of features and matching them against library of stored patterns. (e.g., alphanumeric characters, types of abnormal cells, or human features in the case of biometrics)
  - Pattern (feature) detection is one important component of pattern recognition.
- Computer vision can be used as part of a passive UI, as an alternative to intrusive (tethered) gadgetry such as 6DoF "space mice", wands, and data gloves
- Computational photography draws on many techniques from vision

Other things you can do with an image

- **Overview**
- **Example Applications**
- Jaggies & Aliasing
- Sampling & Duals
- Convolution
- Filtering
- Scaling
- Reconstruction
- Scaling, continued
- Implementation