Review
• Images – an array of colors
• Color – RGBA
• Loading, modifying, updating pixels
• pixels[] as a 2D array
• Simple filters – tinting, grayscale, negative, sepia
• PImage class, fields and methods
• get() method and crumble
• tint() function – color and alpha filtering
• Creative image processing – Pointillism, other shapes

Medical Images

What can you do with Image Processing?
Inspect, Measure, and Count using Photos and Video
http://www.youtube.com/watch?v=KsTINWVhpg
Image Processing Software
http://www.youtube.com/watch?v=1Wip9mGrW3M

Obamicon

Thresholding for Image Segmentation
• Pixels below a cutoff value are set to black
• Pixels above a cutoff value are set to white
Image Enhancement
- Color and intensity adjustment
- Histogram equalization

Histogram Equalization
- Increases the global contrast of images
- So that intensities are better distributed
- Reveals more details in photos that are over or under exposed
- Better views of bone structure in X-rays

Histogram Equalization
- Calculate color frequencies - count the number of times each pixel color appear in the image
- Calculate the cumulative distribution function (cdf) for each pixel color – the number of times all smaller color values appear in the image
- Normalize over (0, 255)

Convolution Filters (Area-based)

Identity
- No change

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Random Neighbor
• Copies randomly from one of the 8 neighbors, and itself

Average – smooth
• Set pixel to the average of all colors in the neighborhood
• Smooths out areas of sharp changes.

Sharpen – High Pass Filter
• Enhances the difference between neighboring pixels
• The greater the difference, the more change in the current pixel

Blur – Low Pass Filter
• Softens significant color changes in image
• Creates intermediate colors

Dilation - Morphology
• Set pixel to the maximum color value within a neighborhood around the pixel
• Causes objects to grow in size.
• Brightens and fills in small holes

Erosion - Morphology
• Set pixel to the minimum color value within a neighborhood around the pixel
• Causes objects to shrink.
• Darkens and removes small objects
Feature Extraction – Region Detection
- Dilate and Erode
  - Open
    - Erode $\rightarrow$ dilate
    - Removes noise
  - Close
    - Dilate $\rightarrow$ Erode
    - Holes are closed

Erode + Dilate to Despeckle

Image Enhancement
- Denoise
  - Averaging
  - Median filter

Image Processing in Processing
- Tint() modulate individual color components
- Blend() combine the pixels of two images in a given manner
- Filter() apply an image processing algorithm to an image

Blend Command
```python
drawImage("colony.jpg");
mask = loadImage("mask.png");
blend(mask, 0, mask.width, mask.height,
0, 0, img.width, img.height, SUBTRACT);
```

Filter Command
```python
filter(THRESHOLD, 0.5);
```

Tint() modulate individual color components
Blend() combine the pixels of two images in a given manner
Filter() apply an image processing algorithm to an image
Image Processing Applications

Manual Colony Counter
http://www.youtube.com/watch?v=7B-9Wf6pENQ

Automated Colony counter
http://www.youtube.com/watch?v=q4rH0jQjBHTag

Measuring Confluency in Cell Culture Biology

- Refers to the coverage of a dish or flask by the cells
- 100% confluence = completely covered

- Image Processing Method
  1. Mask off unimportant parts of image
  2. Threshold image
  3. Count pixels of certain color

Blend: Subtract

Filter: Threshold

Count pixels to quantitate: 5.3% confluency
Vision Guided Robotics
Colony Picking

Predator algorithm for object tracking with learning
http://www.youtube.com/watch?v=1GhNXHCGGsM

Video Processing, with Processing
http://www.youtube.com/watch?v=rKhbUjVYKlC