CSSE463: Image Recognition Day 6

- Yesterday:
  - Local, global, and point operators all operate on entire image, changing one pixel at a time!!
- Lab due tomorrow night, 11:59pm.
- Fruit-finder deadline **Friday**, 11:59pm
  - Please leave time for a solid writeup
  - See updated grading rubric online for standards
  - Questions?
- Today: edge features (another local operator)
  - Sonka 5.3

There are only two people in this world:

1\. Those who index their arrays starting at 1

1\. Those who index their arrays starting at 0

Thanks to 463 student Thomas Root for clarifying this for us.

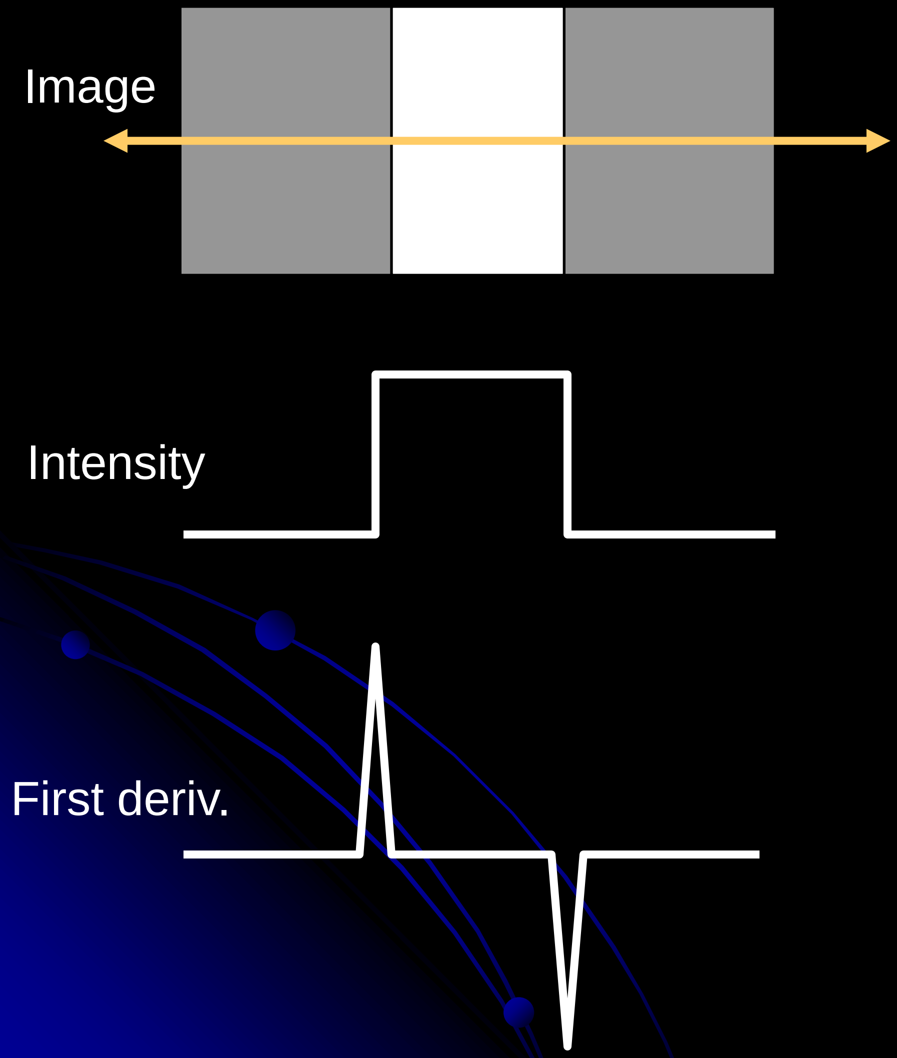
Edge Features – Why?

- “Edginess” (# edges) and their directions can give you info about the scene content
  - Orientation of the image
  - Natural vs. manmade images
- Edges can be used to segment the image.
  - Color information is usually used as well.
  - Specifically, boundaries occur where the chroma and/or luminance change (drastically).
- We choose use to enhance the fruit-finder in a later assignment (*not* now).

Outline for next 2 sessions

- Concept: How to find “edges” in 1D signal
- Edges in 2D images
- Limitations
- Edges vs edgels, Canny edge detector

Intuition: Finding edges



- What's an edge?
- Graph intensity
- How to find changes in intensity?
- How to find first derivative?

Finding derivatives (1D)

- Let y be intensity of point at location x
- Def:

$$\frac{\partial y}{\partial x} \approx \frac{\Delta y}{\Delta x}$$

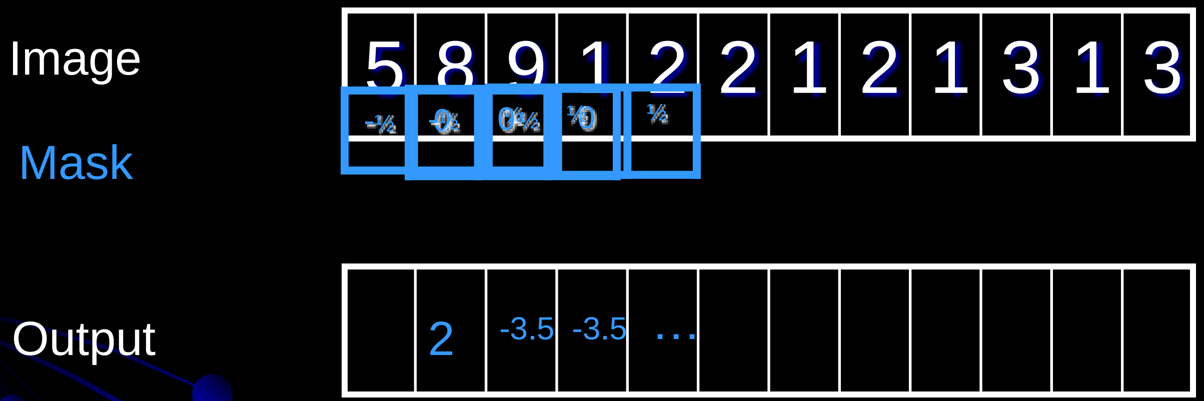
- Fix $\Delta x = 1$ pixel
- $dy/dx = y_2 - y_1$

```
f: [0 0 0 0 0 50 50 50 50 0 0 0 0 0];
f’:[ 0 0 0 0 50 0  0  0 -50 0 0 0 0 ];
```

- Correlate image with filter [-1,1] to find positions of change.
  - Edges “between” pixels.
  - What is significance of magnitude of first deriv. ?

Applying Filters

- *Example for differential with Δx = 2 pixels:*
  (No output “between” pixels)



- ½ Examples for certain types (in notes)
  - *Step edges, ramps, impulse*
- *Properties*
  - *If no contrast?*

Q2,4

Why should the values in an edge filter sum to 0?

- What if they didn't?

- Consider a homogeneous region:
  f: 40, 40, 40, 40, 40, 40

How can we characterize regions of high contrast?

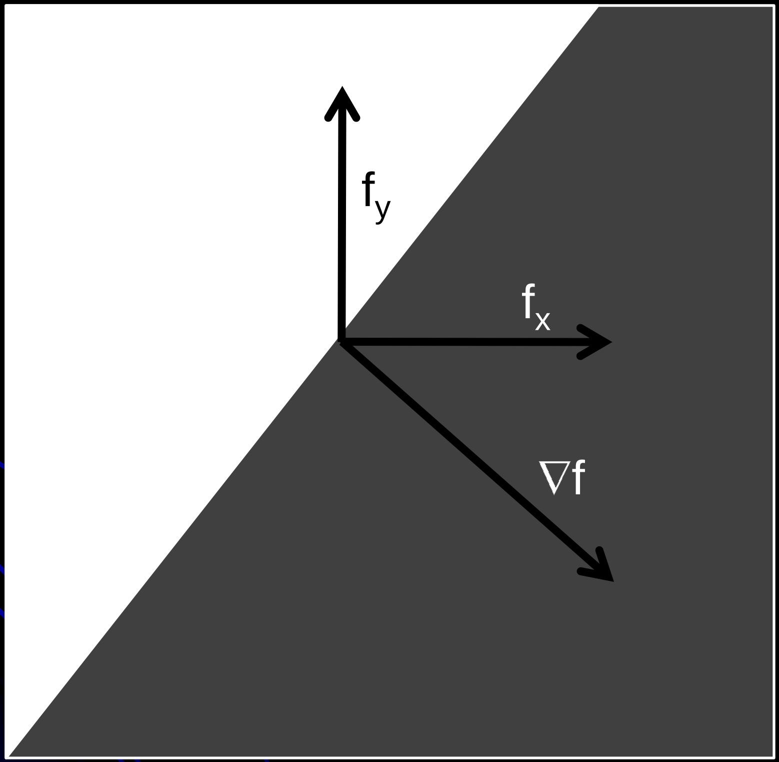
- y’
- y’’

2D Edges

- Local operators
  - Prewitt operators
  - Sobel masks
  - Roberts 2x2 cross-operators
- Gradient: magnitude
- Gradient direction

Gradients

Vector pointing in direction of greatest change:
We want its magnitude and direction



Demo

- My homemade edgefinder
  - Finds vertical and horizontal edges using filters
  - Combines to find edge magnitude
  - Combines to find edge direction
  - Re-scale for display
- Similar to part of Lab 3.
  - So I can't post code

1. Find partials using filters

$$\text{To find } \frac{\delta f}{\delta x}\text{, use Prewitt}: \frac{1}{6}\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} \text{ or Sobel}: \frac{1}{8}\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \text{ filter}$$

$$\text{To find } \frac{\delta f}{\delta y}\text{, use Prewitt}: \frac{1}{6}\begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \text{ or Sobel}: \frac{1}{8}\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \text{ filter}$$

Note that this is 1D filter, but averaged over 3 rows (for df/dx) or 3 cols (for df/dy) and multiplied by 6 to change to integer multiplication

$$\text{Roberts 2x2 cross operators } \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \text{ are more sensitive to noise}$$

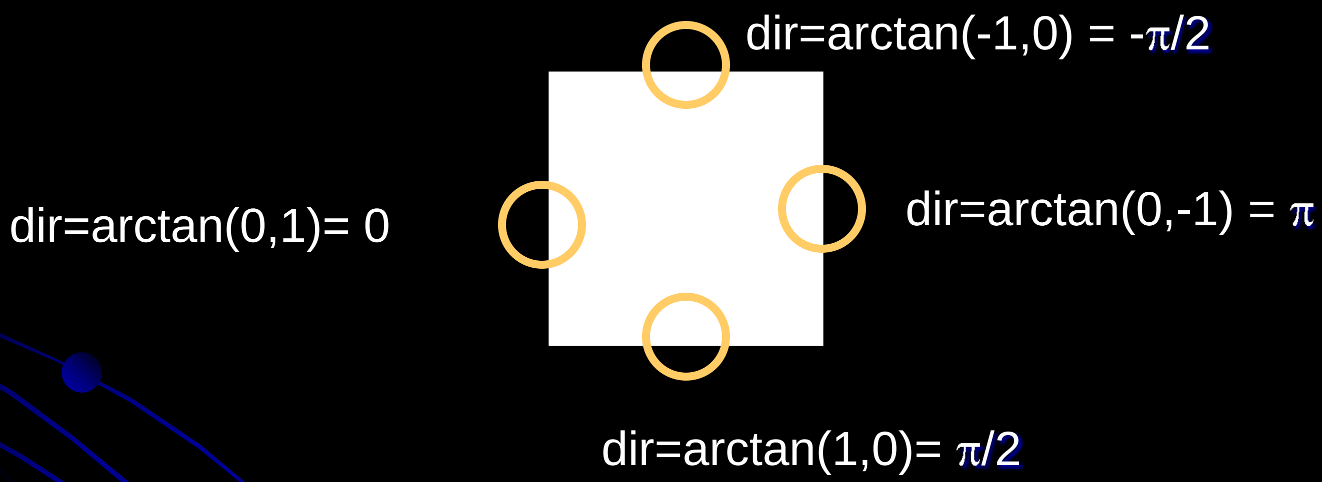
2. Find edge gradient magnitude

- Definition: the gradient, ∇f, is the vector pointing in the direction of greatest change.
- To find its magnitude:

$$|\nabla \mathrm{f}| = \sqrt{\left(\frac{\delta f}{\delta x}\right)^2 + \left(\frac{\delta f}{\delta y}\right)^2}$$

3. Find edge gradient direction

- $\tan^{-1}(y,x)$
- Matlab's atan2(y,x) gives full range, $[-\pi, \pi]$



- Direction is thus the angle formed by the x-axis and the line "pointing towards" light region.

Color edges

- Rarely used historically
- Intuition: edges occur between regions of different hue but same intensity.
- One technique patented by David Cok, Eastman Kodak Co.

Limitations of edgel-finders

- Natural variation
  - Shadows and highlights can obscure edges
- Internal vs. external edges
  - We might want the outline of an article of clothing, but the stripes in our shirt are edges too.
- Noise!
  - Signal-to-noise ratio important in determining how hard it is to find edges.

Edgels vs. Edges

- *Edgels* are unconnected groups of pixels detected by a mask
- *Edges* are longer segments found by grouping edgels
    - Intuitively, we think of edges
- How might you process a “raw” edge image?

From mask output to edgels: ideas

- Threshold away "weak" output
  - What threshold to use?
  - Always fixed or should it vary?
- "Thin" edges by nonmaximum suppression.
  - Idea: If an edge is 5 pixels wide, we can replace it with only the innermost segment.
  - Remove the edge response of an pixel not greater than its 2 neighbors in the direction of the gradient.

Canny edge detection

- First smoothes the intensity image
  - Parameter σ controls how many edges found
- Non-maximal suppression
- Uses two thresholds:
  - High: to initiate contour following
  - Low: to follow along a contour
  - Result: segments from noise are less likely to be found (unless the noise is too strong)
- Aggregates neighboring edgels into curves ("edges")

Canny edge detection

- You'll get to play with various edgefinders in Lab2 using Matlab's built-in *edgedemo*