Edge Detection

Winter in Kraków photographed by Marcin Ryczek

CS194: Image Manipulation, Comp. Vision, and Comp. Photo
Alexei Efros, UC Berkeley, Spring 2020
Edge detection

- **Goal:** Identify sudden changes (discontinuities) in an image
  - Intuitively, most semantic and shape information from the image can be encoded in the edges
  - More compact than pixels

- **Ideal:** artist’s line drawing (but artist is also using object-level knowledge)

Source: D. Lowe
Origin of edges

Edges are caused by a variety of factors:

- surface normal discontinuity
- depth discontinuity
- surface color discontinuity
- illumination discontinuity

Source: Steve Seitz
Closeup of edges
Closeup of edges
Closeup of edges
Closeup of edges
Characterizing edges

- An edge is a place of rapid change in the image intensity function.
There is ALWAYS a tradeoff between smoothing and good edge localization!

Image with Edge

Edge Location

Image + Noise

Derivatives detect edge and noise

Smoothed derivative removes noise, but blurs edge
The Canny edge detector

norm of the gradient
The Canny edge detector

thresholding
The Canny edge detector

How to turn these thick regions of the gradient into curves?
Non-maximum suppression

Check if pixel is local maximum along gradient direction, select single max across width of the edge
Non-Local Maxima Suppression

Gradient magnitude at center pixel is lower than the gradient magnitude of a neighbor in the direction of the gradient ➔ Discard center pixel (set magnitude to 0)

Gradient magnitude at center pixel is greater than gradient magnitude of all the neighbors in the direction of the gradient ➔ Keep center pixel unchanged
Non-maximum suppression

requires checking interpolated pixels p and r
The Canny edge detector

Problem: pixels along this edge didn’t survive the thresholding

thinning
(non-maximum suppression)
Hysteresis thresholding

Use a high threshold to start edge curves, and a low threshold to continue them.

Source: Steve Seitz
Two thresholds applied to gradient magnitude
Hysteresis Thresholding

Weak pixels but connected

Weak pixels but isolated

Very strong edge response. Let’s start here

Weaker response but it is connected to a confirmed edge point. Let’s keep it.

Continue….

Note: Darker squares illustrate stronger edge response (larger $M$)
Recap: Canny edge detector

1. Filter image with derivative of Gaussian
2. Find magnitude and orientation of gradient
3. **Non-maximum suppression:**
   - Thin wide “ridges” down to single pixel width
4. **Linking and thresholding (hysteresis):**
   - Define two thresholds: low and high
   - Use the high threshold to start edge curves and the low threshold to continue them

MATLAB: `edge(image, 'canny');`

Edge detection is just the beginning…

Berkeley segmentation database:
http://www.eecs.berkeley.edu/Research/Projects/CS/vision/grouping/segbench/
two-tone images
“attached shadow” contour

“cast shadow” contour

hair (not shadow!)

inferred external contours