# ISTA 352

# Lecture 33

# Image Analysis (II, mostly about filters)

## Administrivia

- Quiz 3 next time, material up to the end of Nov 09
  - Specifically, up to the end of the introduction of linear filters
  - We will review the key notions today before continuing with filters
  - Test topics
    - Some review questions
    - Mostly about scientific imaging and images in science
    - Perhaps a few general questions on image processing and analysis
    - Perhaps a few questions on linear filtering

Review

## Linear Filtering

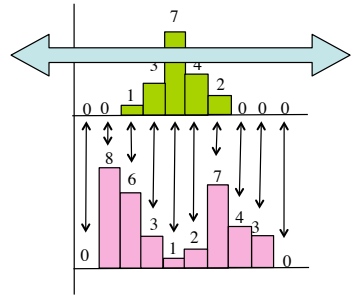
- Important class of filters
- Examples from before that are linear
  - Block averaging
  - Replace pixel with local change estimated by the difference between a pixel and its neighbors
- Examples of non linear filters
  - Median filter

Review

## Linear Filtering

- Basic operation is a **dot product** between pixels values in "block", and those in a "filter".
- In one dimension

Weights (kernel)




Multiply lined up pairs of numbers and then sum up

Signal

Review

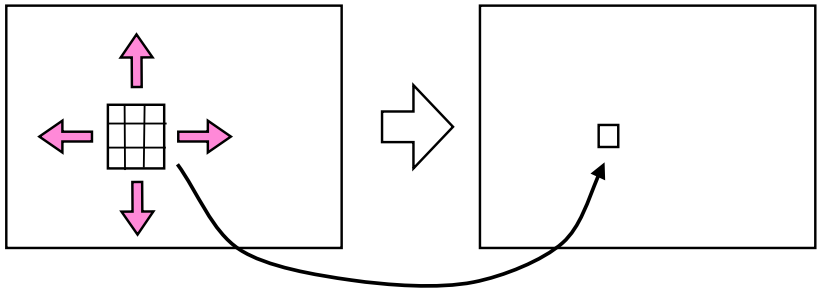
# Linear Filtering

- Basic operation is a **dot product** between pixels values in "block", and those in a "filter".
- These words all refer to the same thing
  - filter
  - mask
  - weights
  - kernel

Review

# Linear Filtering (2D)

Gray scale image (matrix)



Compute product of the weights in the mask with corresponding image ones, and sum up (dot product)

Result goes into a new image at the same place as the mask location

Then slide mask over one pixel and do it again (etc.)

Review

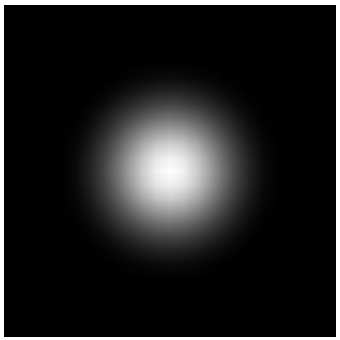
# Linear Filter Examples

Replace each pixel with the the average of itself and immediate neighbors (block average)

| | | |
|---|---|---|
| 1/9 | 1/9 | 1/9 |
| 1/9 | 1/9 | 1/9 |
| 1/9 | 1/9 | 1/9 |

Review

# An Isotropic Gaussian Filter



- The picture shows a smoothing kernel proportional to

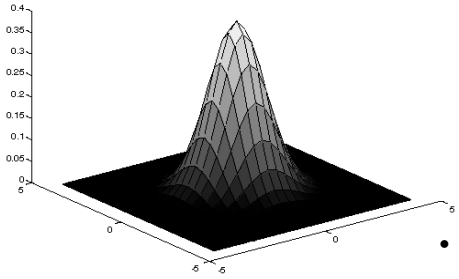
$$\exp\left(-\left(\frac{x^2+y^2}{2\sigma^2}\right)\right)$$

(a reasonable model of a circularly symmetric fuzzy blob)

- The Gaussian filter is the standard way to smooth images

Review

# An Isotropic Gaussian Filter




- The picture shows a smoothing kernel proportional to

$$\exp\left(-\left(\frac{x^2+y^2}{2\sigma^2}\right)\right)$$

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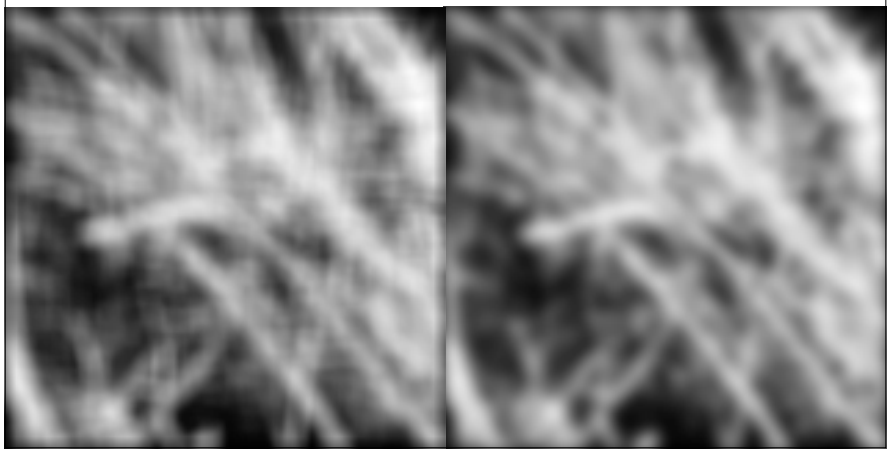
- The Gaussian filter is the standard way to smooth images

Review

# Block Averaging

**Gaussian**



Review

# Image Scale

- The difference between a tree in the distance, and its leaves up close, is one of image scale
- An arbitrary image will have multiple arbitrary scales
- Typically we analyze images at various scales
- A good way to think of rescaling an image is to smooth with a Gaussian and sub sample the results.

Review

512 256 128 64 32 16 8

# Linear Filter Examples

Review (concept, not particular example)

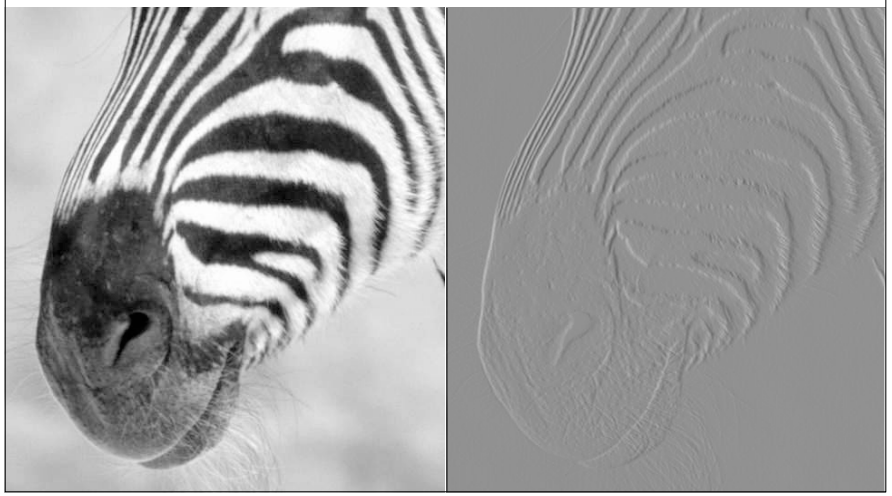
Suppose you wanted a filter to respond to the changes (edges) in an image.

Simple differencing operator (horizontal direction).

| | |
|---|---|
| 1 | -1 |

# Finite differences (x-direction)

Review (concept, not particular example)



# Linear Filtering as Functions

- Because the fundamental operation is a dot product, the filtering method just described is linear
- Specifically, given the filtering operation defined by the mask $M$, denoted by $f_M()$, we have

$$f_M\left(a\,I_1 + b\,I_2\right) = a\,f_M\left(I_1\right) + b\,f_M\left(I_2\right)$$

- Exercises
  - Verify this is true for one of the linear function examples
  - Verify this is not always true for max() and median()