EEE-6512: Image Processing and Computer Vision

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Lecture #8: Edges and Features

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Chapter Outline

- Course Recap
- Going Forward
- Computer Vision Overview
- Multiresolution Processing
- Edge Detection
- Approximating Intensity Edges with Polylines
- Feature Detectors
- Feature Descriptors

What have we covered so far? (Image Processing)

- Introduction
- Fundamentals of Imaging
- Point and Geometric Transformations
- Binary Image Processing
- Spatial Domain Filtering
- Frequency Domain Filtering

Going Forward

- Edges and Features
- Segmentation
- Model Fitting
- Classification
- Color*

Computer Vision

What is computer vision?

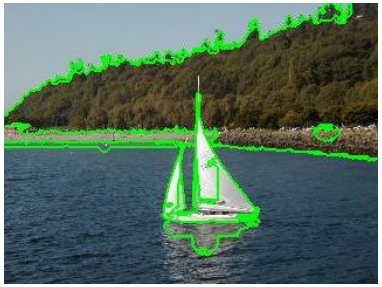
- Enabling computers to "see" – extract information from the world by processing images obtained from visual sensors
- A sensor modality for robotics
- Computer emulation of human vision
- Inverse of Computer Graphics (Image Model -> World Model)

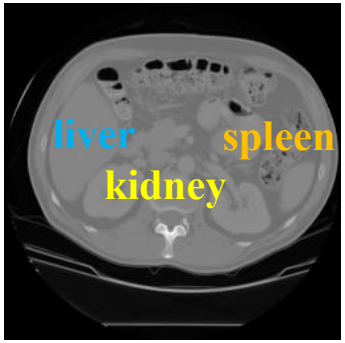
"Two cars are parked in front of a large gothic building during the day, after a heavy rain"

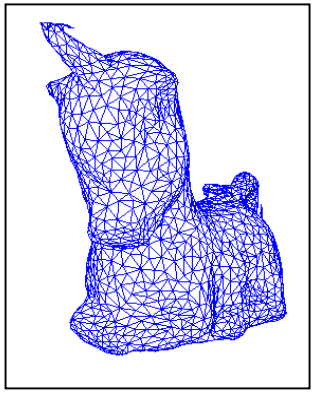
- **Used to solve:**
  - classification
  - tracking
  - structure from X

Goals of Computer Vision

- Segment an image into useful regions
- Perform measurements on certain areas
- Determine what object(s) are in the scene
- Calculate the precise location(s) of objects
- Visually inspect a manufactured object
- Construct a 3D model of the imaged object
- Find "interesting" events in a video







The Three Stages of Computer Vision

- **low-level**

image → **image**

- **mid-level**

image → **features**

- **high-level**

features → **analysis**

Low-Level

Sharpening

Blurring

Low-Level

Canny

Original Image

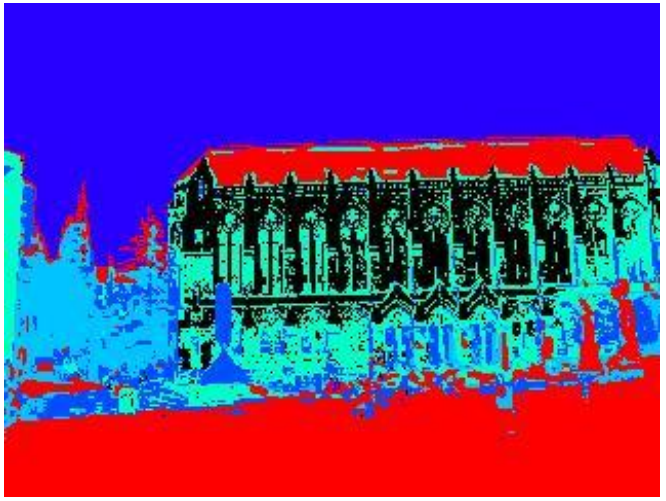
Edge Image

Mid-Level

original color image

K-means clustering

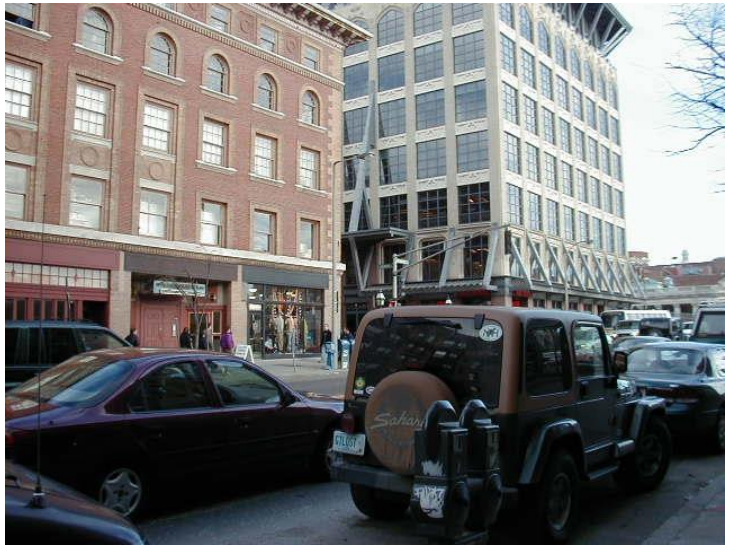
(followed by connected component analysis)



regions of homogeneous color

data structure

Low- to High-Level



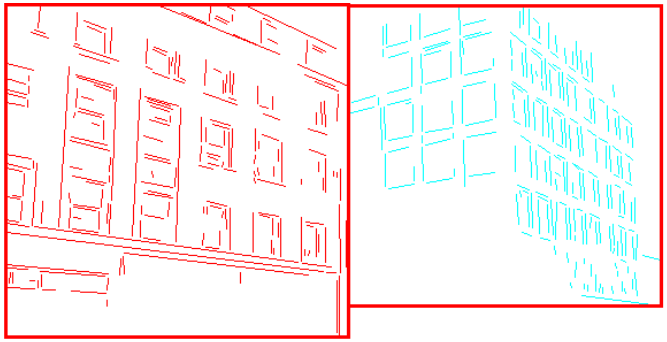
low-level

edge image

mid-level

consistent line clusters

high-level



Building Recognition

Why is computer vision hard?






- What do the pictures show? Easy. What algorithm did you use? Difficult.
- Lots of invariants: pose, scale, lighting, color, shape, occlusion
- Context plays a big role.

What does Computer Vision Involve?

- Image Processing (Pre-processing)
- **Feature Extraction***
- Pattern Recognition / Machine Learning

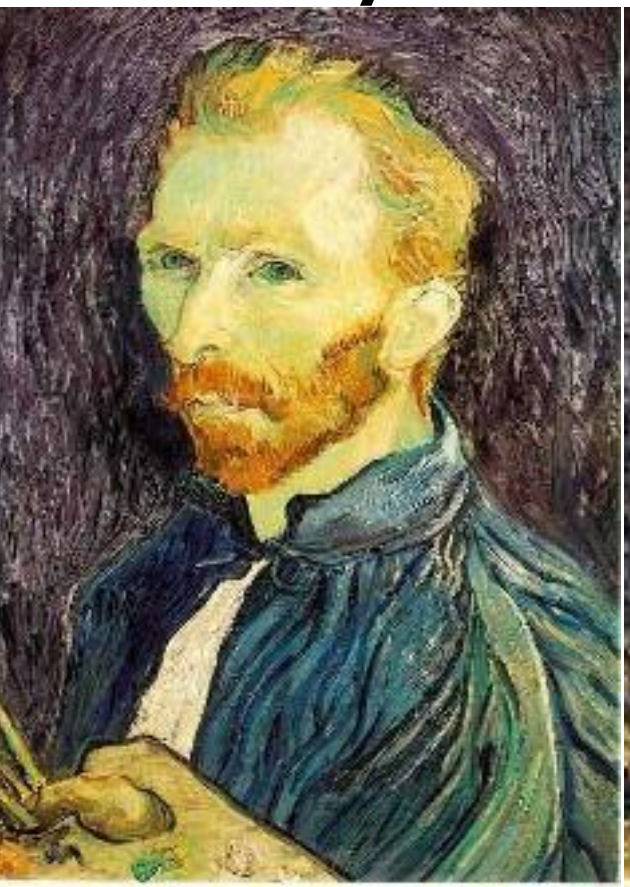
Edges and Features

Image Pyramids: What are they good for?

- **Improve Search**
  - Search over translations
    Classic coarse-to-fine strategy
  - Search over scale
    - Template matching
    - E.g. find a face at different scales
- **Precomputation**
  Need to access image at different blur levels
- **Image Processing**
  - Editing frequency bands separately
  - E.g. image blending…

Dropping Pixels v.s. Smoothing and then dropping Pixels

Why does this look so bad?



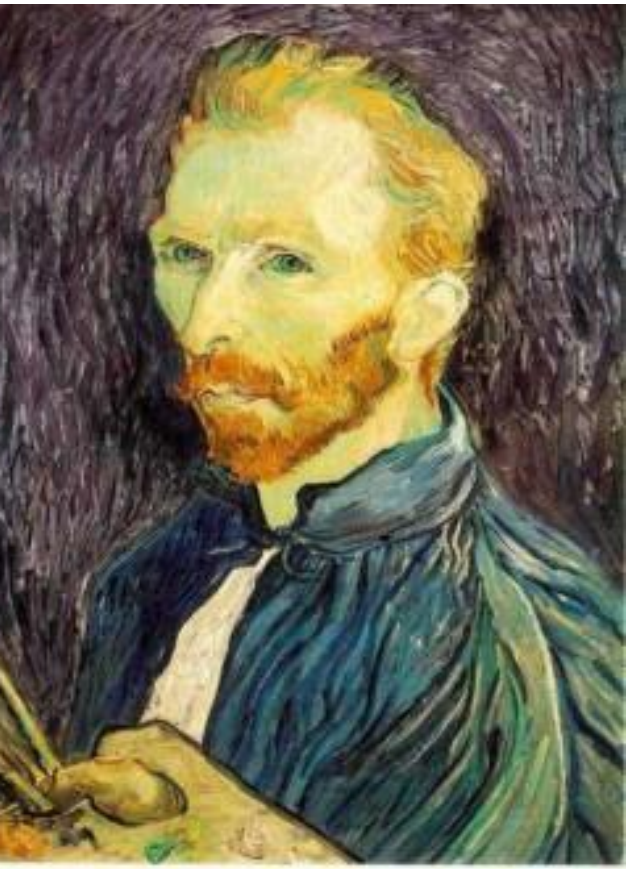
1/2

1/4 (2x zoom)

1/8 (4x zoom)

[From Alexei Efros' lecture on Sampling and Pyramids]

Subsampling with Gaussian pre-filtering



Gaussian 1/2

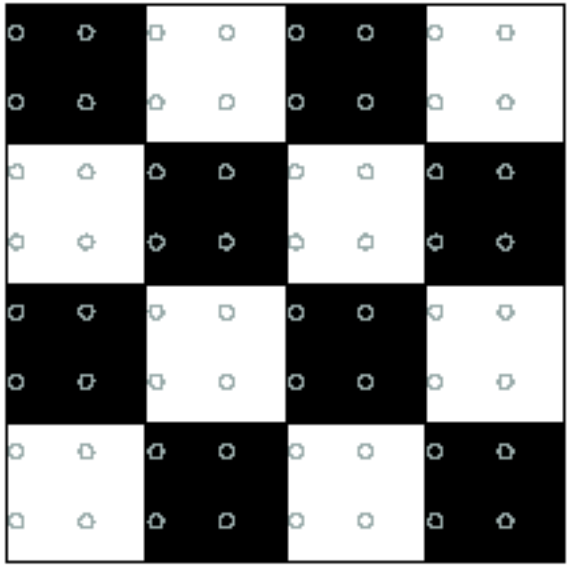
G 1/4

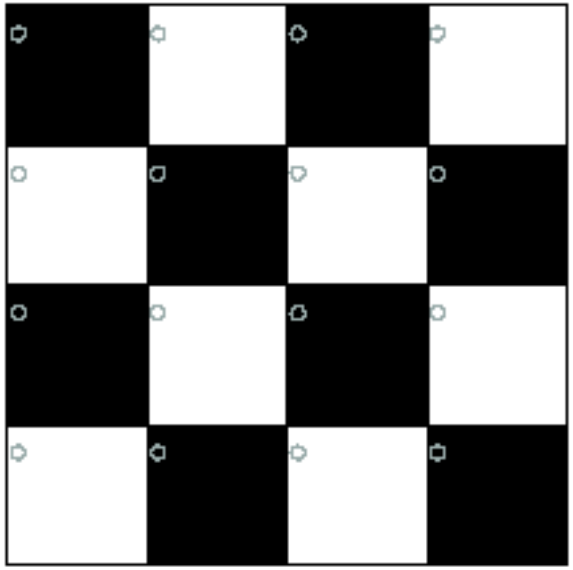
G 1/8

- Solution: filter the image, *then* subsample
  - Filter size should double for each ½ size reduction.

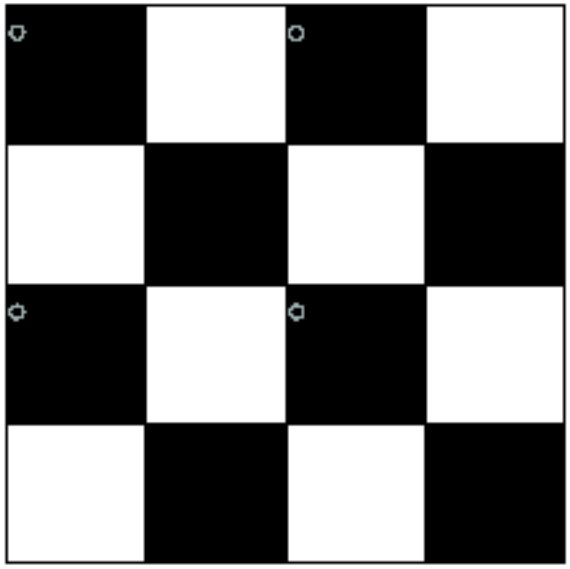
[From Alexei Efros' lecture on Sampling and Pyramids]

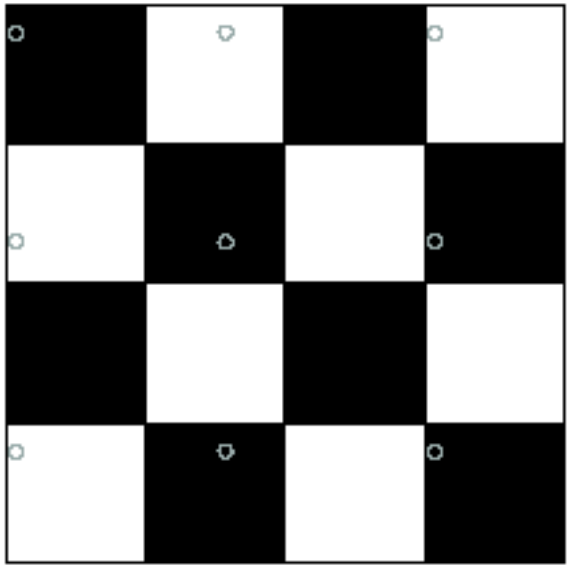
Sampling





Good sampling:
- Sample often or,
- Sample wisely

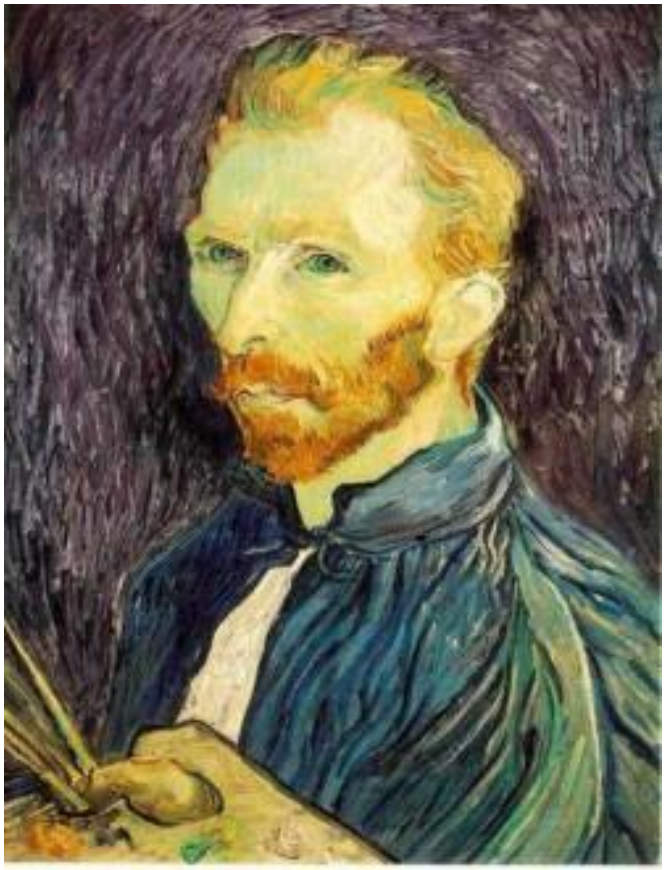




Bad sampling:
- see aliasing in action!

[From Alexei Efros' lecture on Sampling and Pyra

Gaussian pre-filtering



Gaussian 1/2

G 1/4

G 1/8

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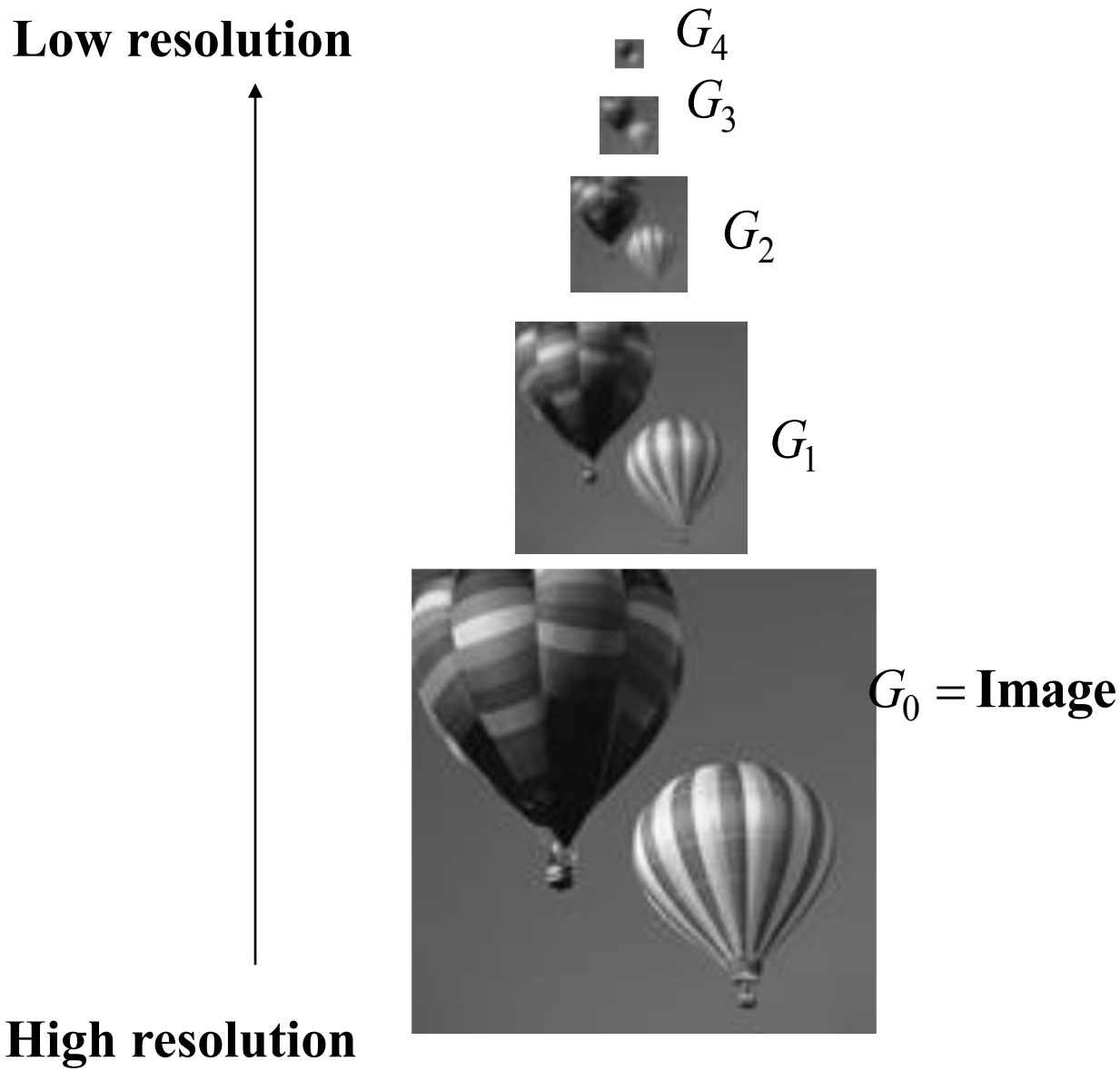
The Gaussian Pyramid

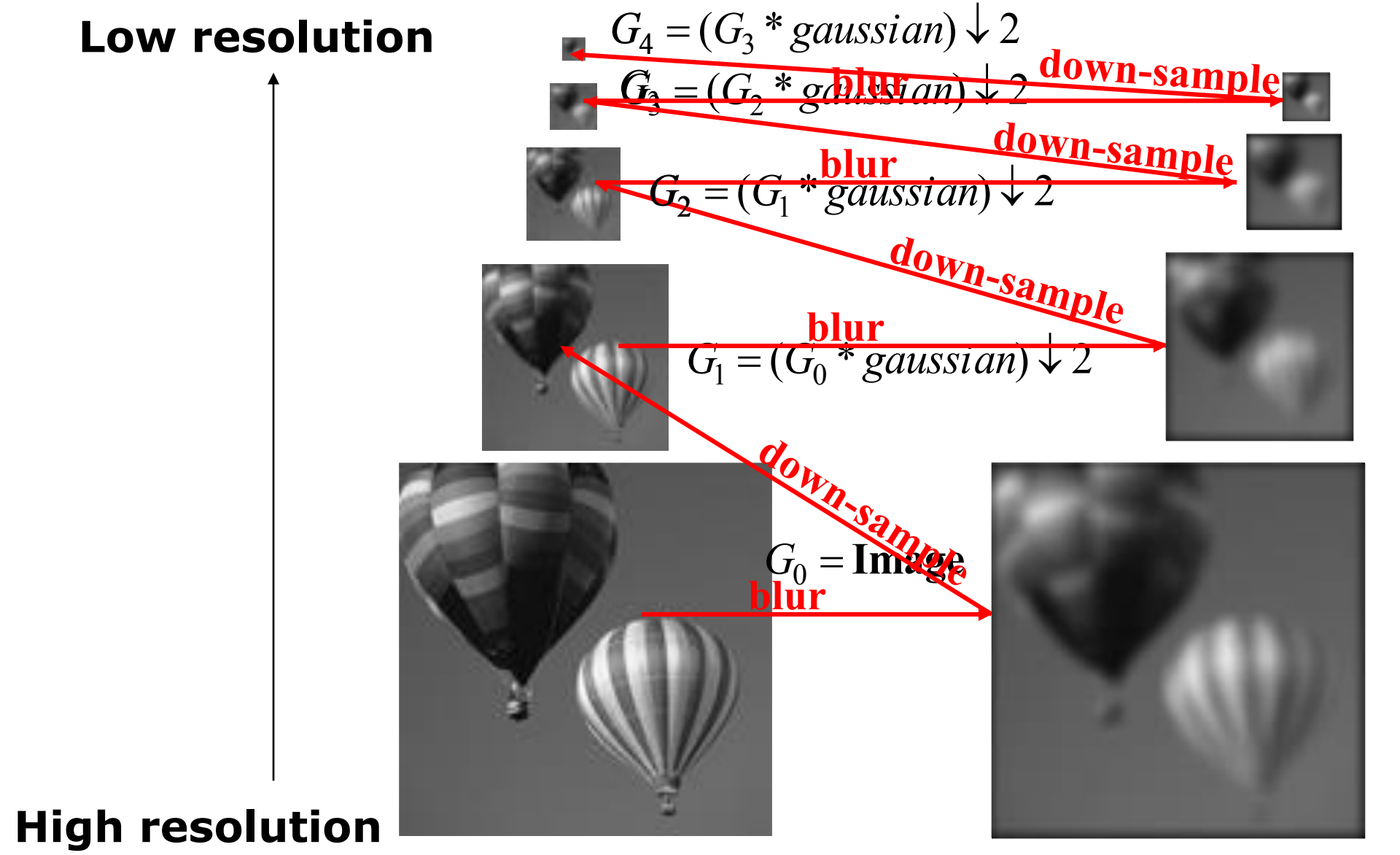


[www.wisdom.weizmann.ac.il/~mblank/CVfall04/handouts/lec4.ppt]

Gaussian Pyramid

- A face that appears to occupy a 40 X 40 region in the original image will occupy only a 20 X 20 region in the downsampled image, a 10 X 10 region in the twice downsampled image, and so forth.
  - Because each successive image is smaller than its predecessor, stacking the images on top of one another yields the shape of a pyramid.
  - The sequence of images is known as an **image pyramid**.
- The most popular way to smooth an image is to convolve with a Gaussian kernel, leading to a **Gaussian pyramid**.

The Gaussian Pyramid



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Questions?