Descriptors III

CSE 576

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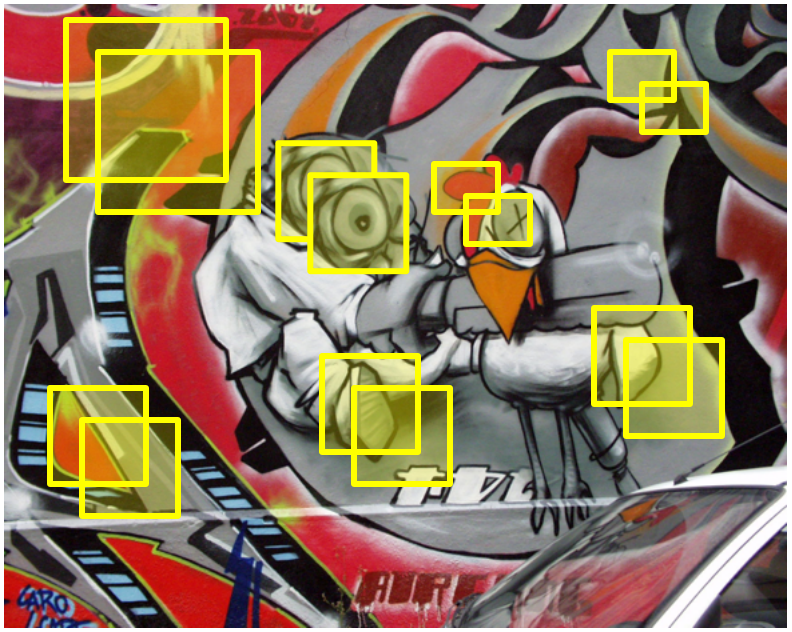
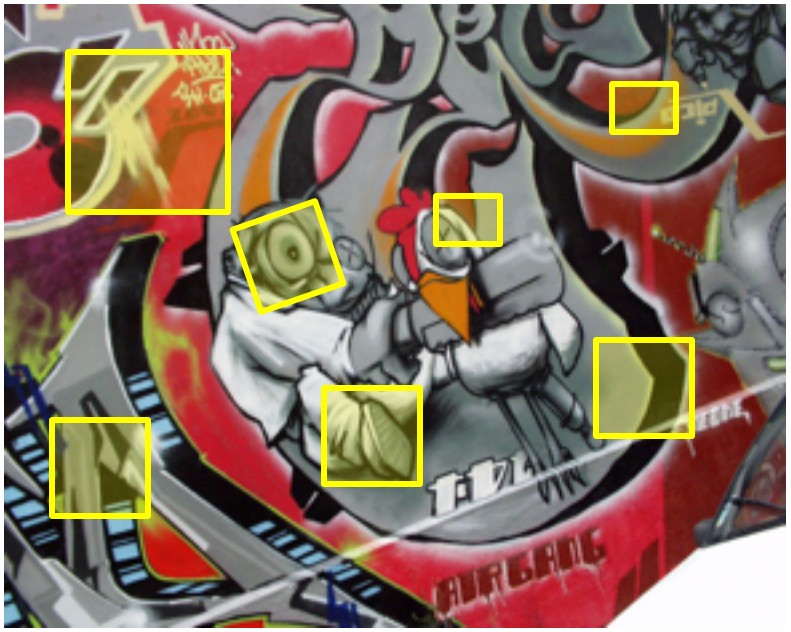
Many slides from Larry Zitnick, Steve Seitz

How can we find corresponding points?

How can we find correspondences?

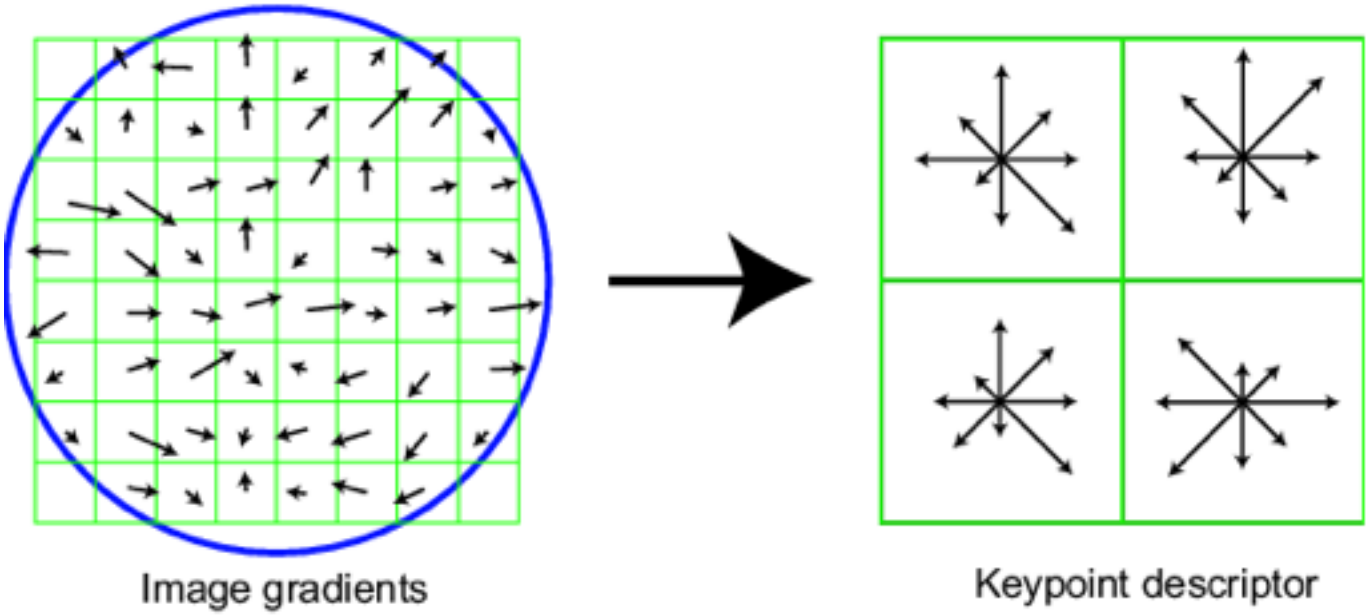




SIFT descriptor

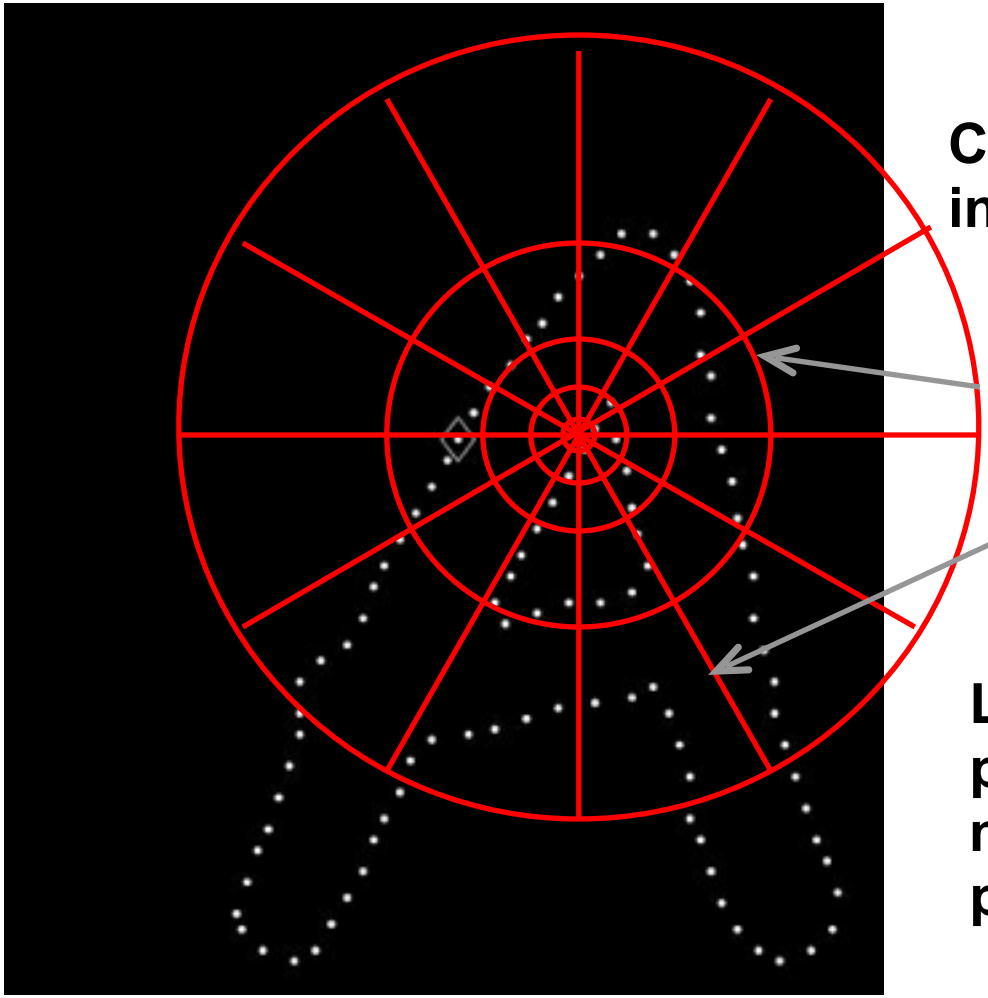
Full version

- Divide the 16x16 window into a 4x4 grid of cells (2x2 case shown below)
- Compute an orientation histogram for each cell
- 16 cells * 8 orientations = 128 dimensional descriptor



Adapted from slide by David Lowe

Local Descriptors: Shape Context



Count the number of points inside each bin, e.g.:

Count = 4

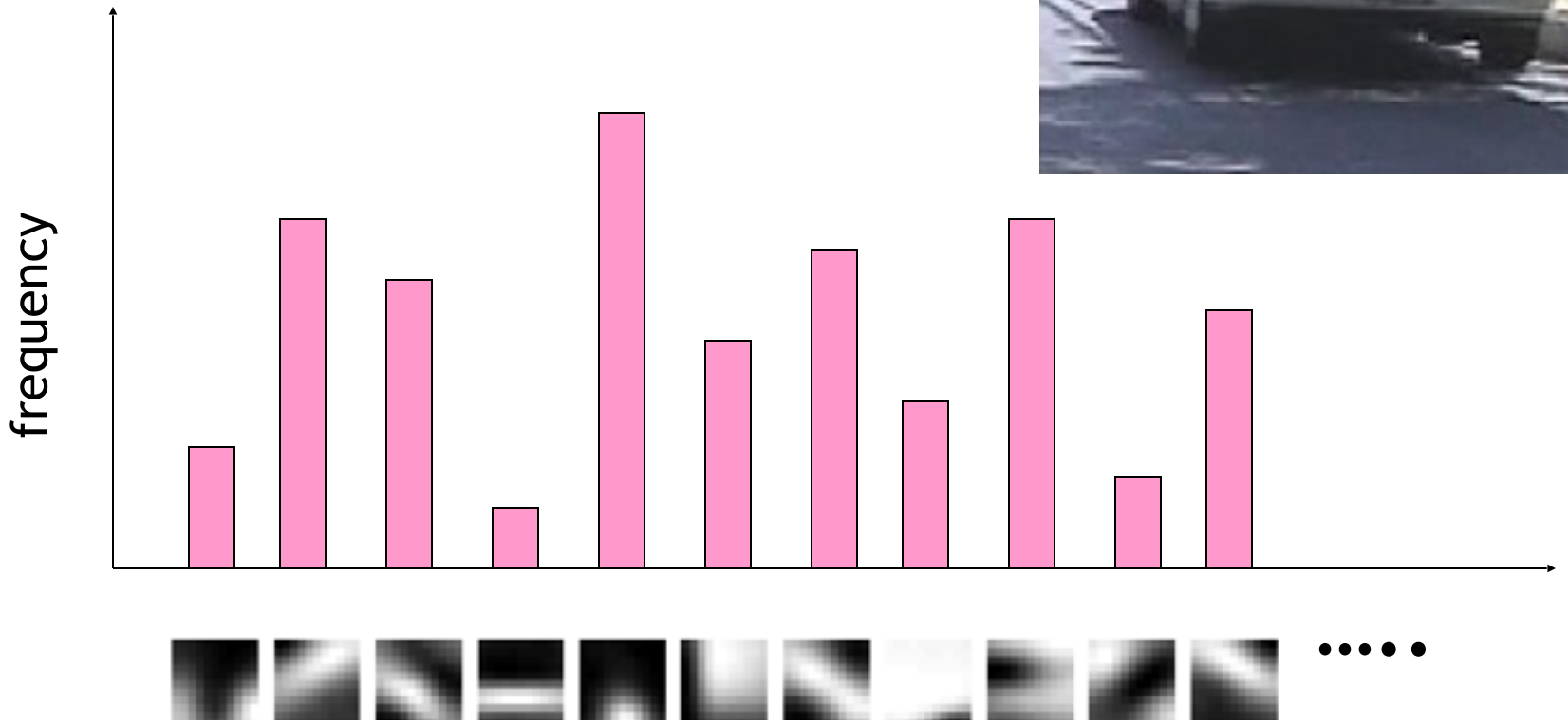
⋮

Count = 10

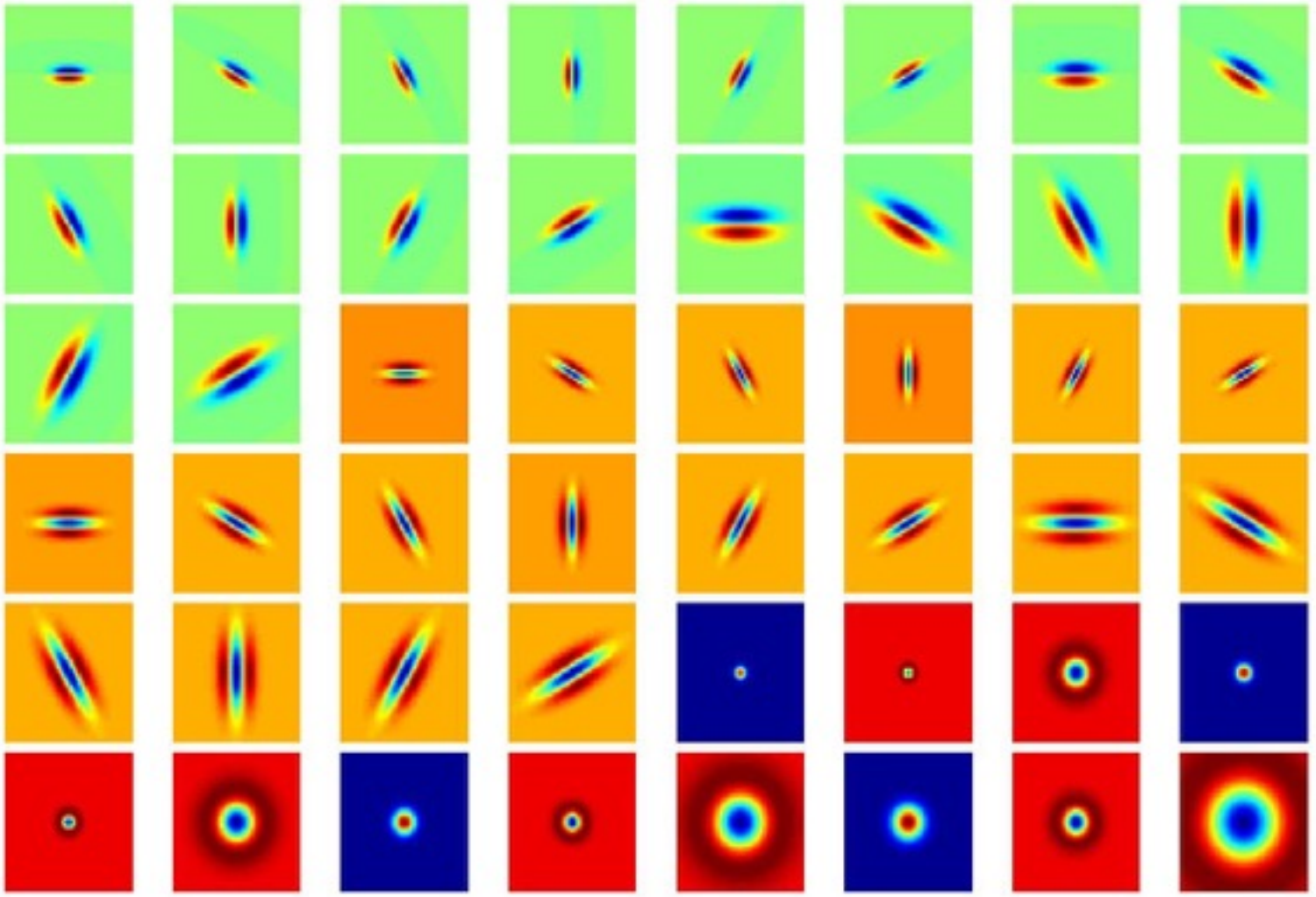
Log-polar binning: more precision for nearby points, more flexibility for farther points.

Belongie & Malik, ICCV 2001

Bag of Words

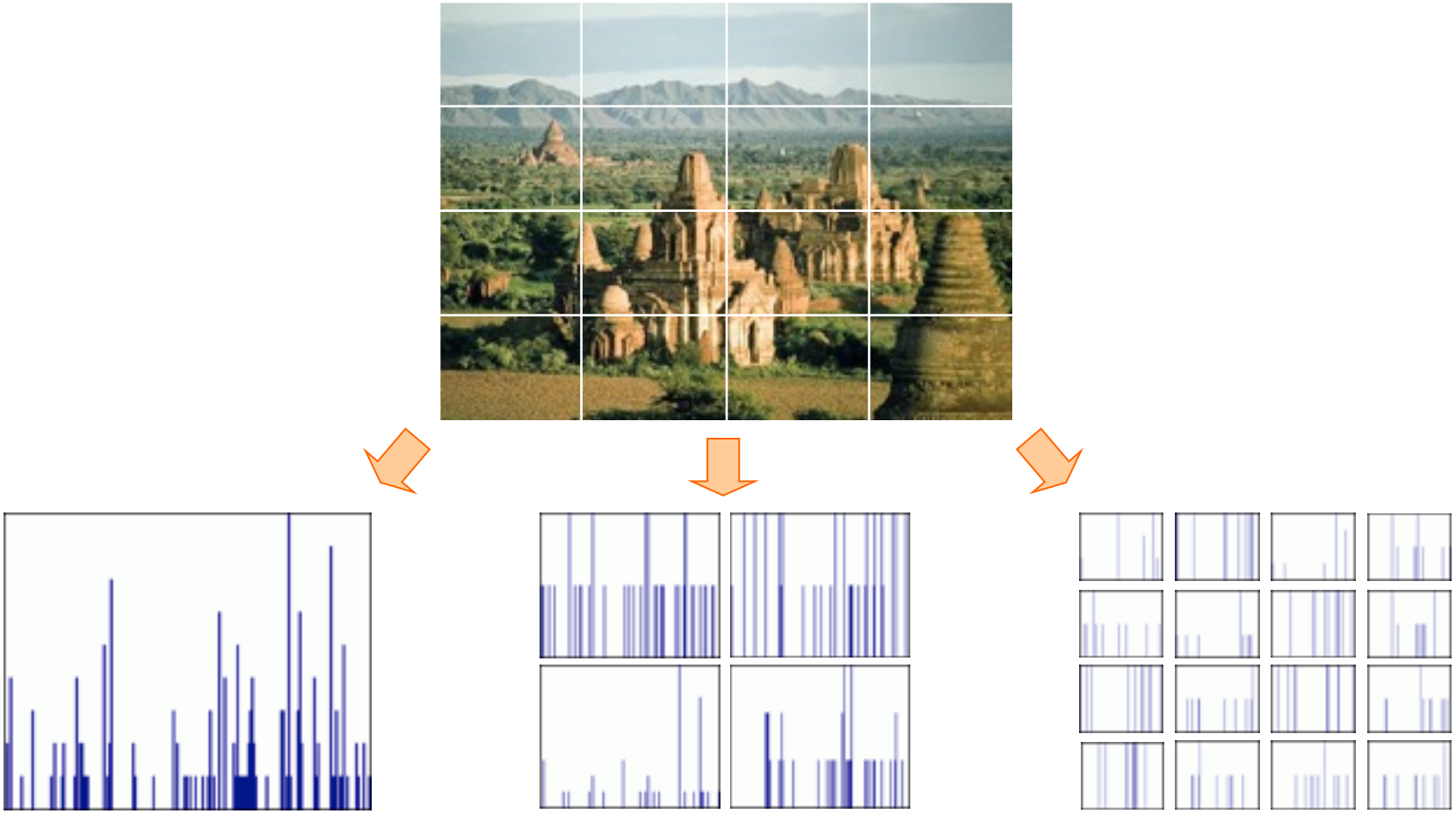


Another Representation: Filter bank



Spatial pyramid representation

- Extension of a bag of features
- Locally orderless representation at several levels of resolution



What about Scenes?

Demo : Rapid image understanding

By Aude Oliva

Instructions: 9 photographs will be shown for half a second each. Your task is to **memorize these pictures**

Credit: A. Torralb

Credit: A. Torralb

Credit: A. Torralb

Credit: A. Torralb

Credit: A. Torralb

Credit: A. Torralb

Credit: A. Torralb

Credit: A. Torralb

Credit: A. Torralb

Memory Test

Which of the following pictures have you seen ?

If you have seen the image
clap your hands once

Credit: A. Torralba

Have you seen this picture ?

Credit: A. Torralb

Credit: A. Torralb

Have you seen this picture ?

Credit: A. Torralb

NO

Have you seen this picture ?

NO

Have you seen this picture ?

Credit: A. Torralb

Have you seen this picture ?

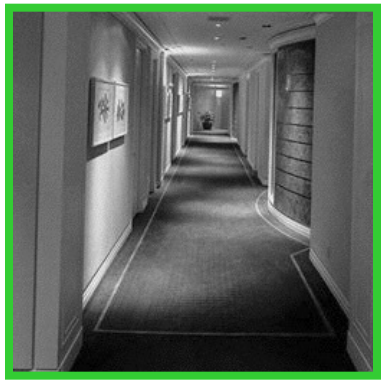
Credit: A. Torralb

Have you seen this picture ?

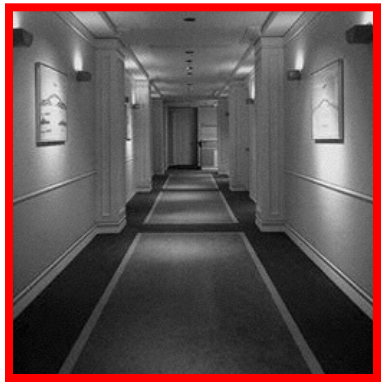
Credit: A. Torralb

Credit: A. Torralb

You have seen these pictures



You were tested with these pictures



The gist of the scene

In a glance, we remember the meaning of an image and its global layout but some objects and details are forgotten

Holistic scene representation: Shape of a scene

- Finding a low-dimensional "scene space"
- Clustering by humans
  - Split images into groups
  - ignore objects, categories

Table 1. Spatial envelope properties of environmental scenes.

Property	S1	S2	S3	Total
Naturalness	65	12	0	77
Openness	6	53	24	83
Perspective	6	18	29	53
Size	0	0	47	47
Diagonal plane	0	12	29	41
Depth	18	12	29	59
Symmetry	0	0	29	29
Contrast	0	0	18	18

Results are in %, for each of the three experimental steps. The total represents the percent of times the attribute has been used regardless of the stage of the experiment.

Spatial envelope properties

- Naturalness
  - natural vs. man-made environments

Spatial envelope properties

- Openness
  - decreases as number of boundary elements increases

Spatial envelope properties

- Roughness
  - size of elements at each spatial scale, related to fractal dimension

Spatial envelope properties

- Expansion (man-made environments)
  - depth gradient of the space

Spatial envelope properties

- Ruggedness (natural environments)
  - deviation of ground relative to horizon

Scene statistics

- DFT (energy spectrum)
  - throw out phase function (represents local properties)
- Windowed DFT (spectrogram)
  - Coarse local information
  - 8x8 grid for these results

Scene statistics

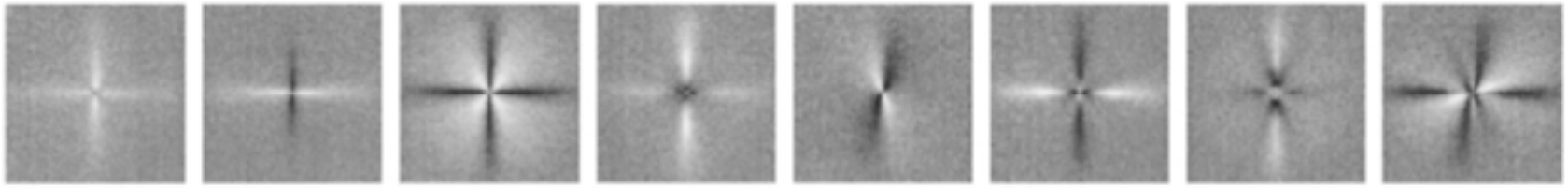


Figure 2. The first eight principal components for energy spectra of real-world scenes. The frequency $f_x = f_y = 0$ is located at the center of each image.

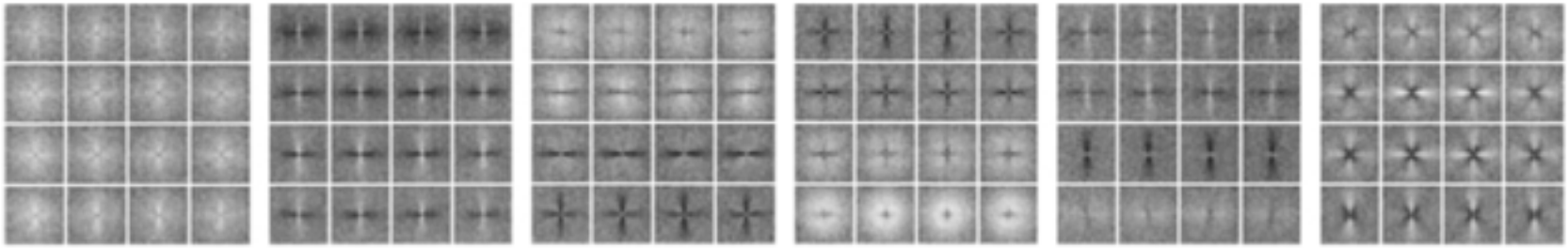
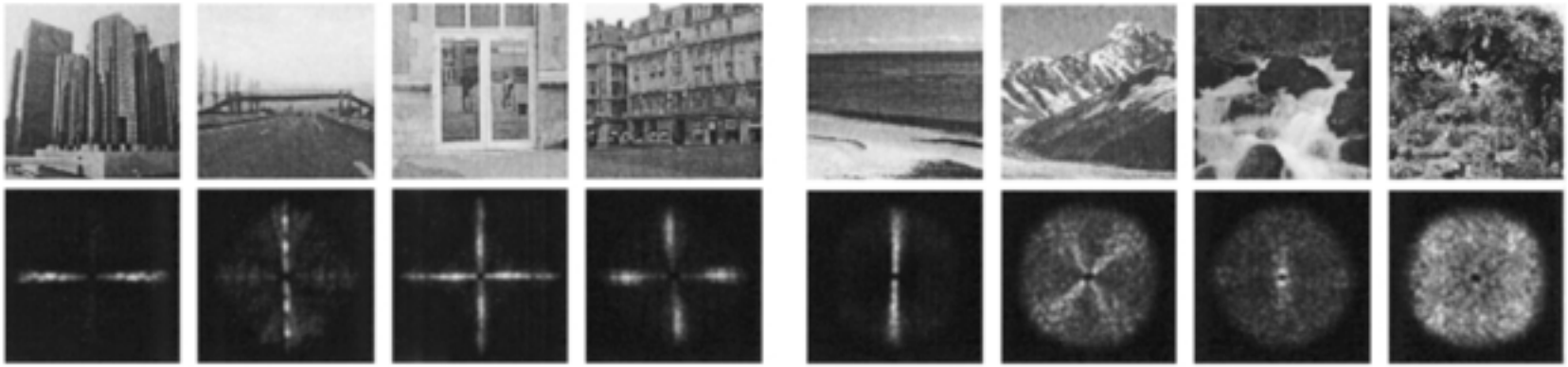


Figure 3. The first six principal components of the spectrogram of real-world scenes. The spectrogram is sampled at 4×4 spatial location for a better visualization. Each subimage corresponds to the local energy spectrum at the corresponding spatial location.

Scene classification from statistics

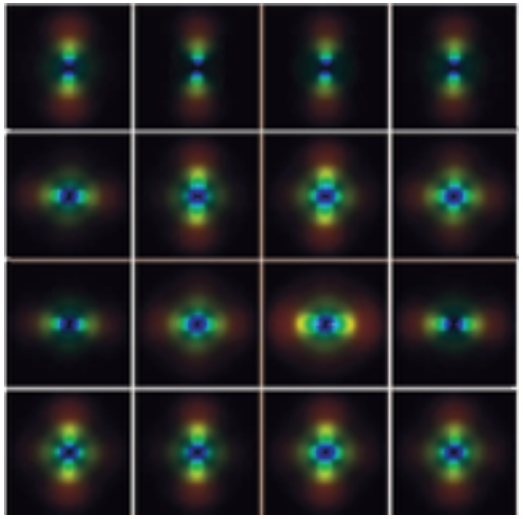
- Different scene categories have different spectral signatures
  - Amplitude captures roughness
  - Orientation captures dominant edges



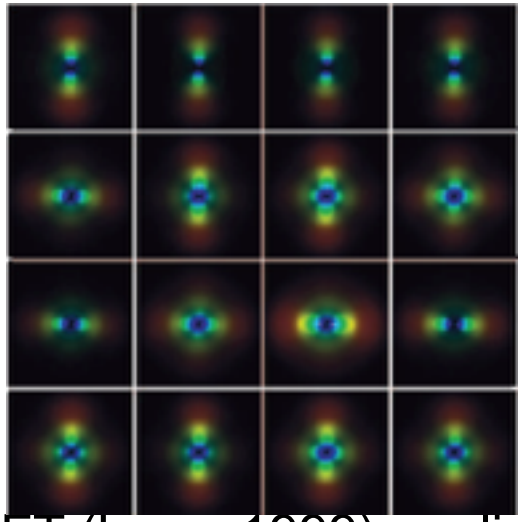
Learning the spatial envelope

- Use linear regression to learn
  - DST (discriminant spectral template)
  - WDST (windowed discriminant spectral template)
- Relate spectral representation to each spatial envelope feature

Gist descriptor



Oliva and Torralba, 2001



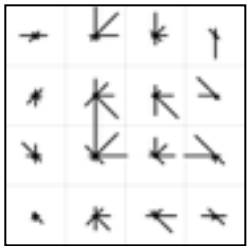
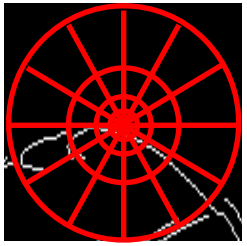
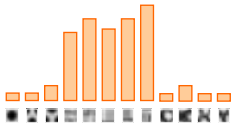
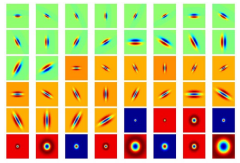
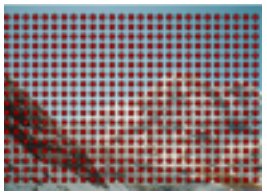
8 orientations
4 scales
x 16 bins
512 dimensions

Similar to SIFT (Lowe 1999) applied to the entire image

M. Gorkani, R. Picard, ICPR 1994; Walker, Malik. Vision Research 2004; Vogel et al. 2004;
Fei-Fei and Perona, CVPR 2005; S. Lazebnik, et al, CVPR 2006; …

Example visual gists

Oliva & Torralba (2001)

Features

- Where:
  - Interest points
    - Corners
    - Blobs
  - Grid
  - Spatial Pyramids
  - Global
- What: (Descriptors)
  - Sift, HOG
  - Shape Context
  - Bag of words
  - Filter banks