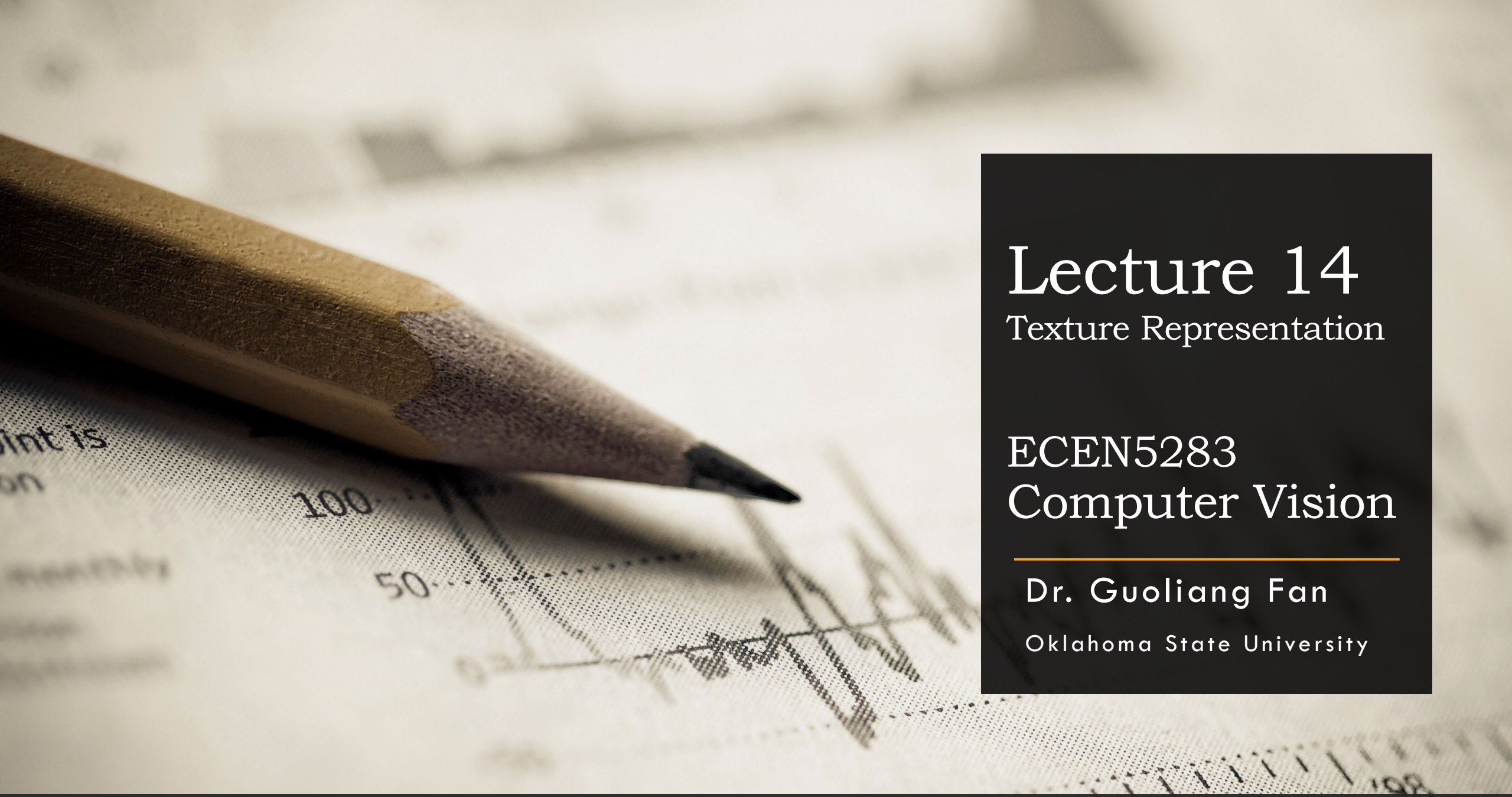

Lecture 14

Texture Representation

ECEN5283 Computer Vision

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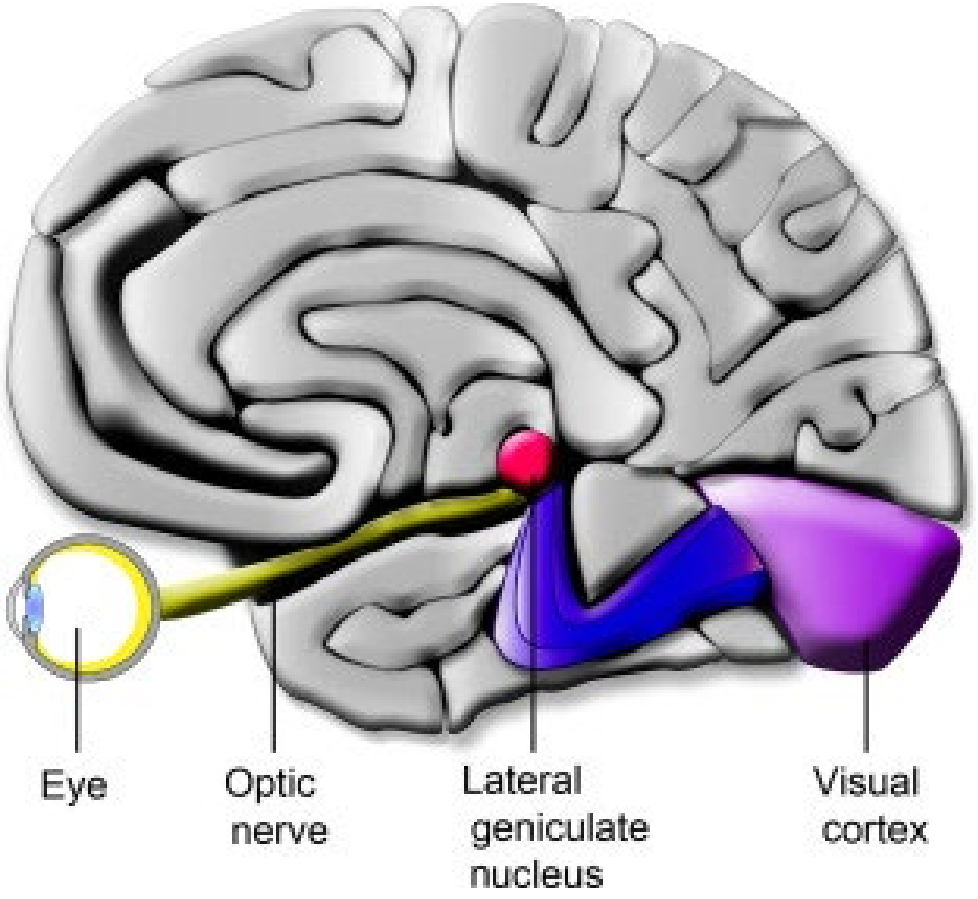
Goals

To represent textures by a filter bank.

To discuss two issues of texture representation by filter banks:

- statistics and scales

Human Visual Cortex



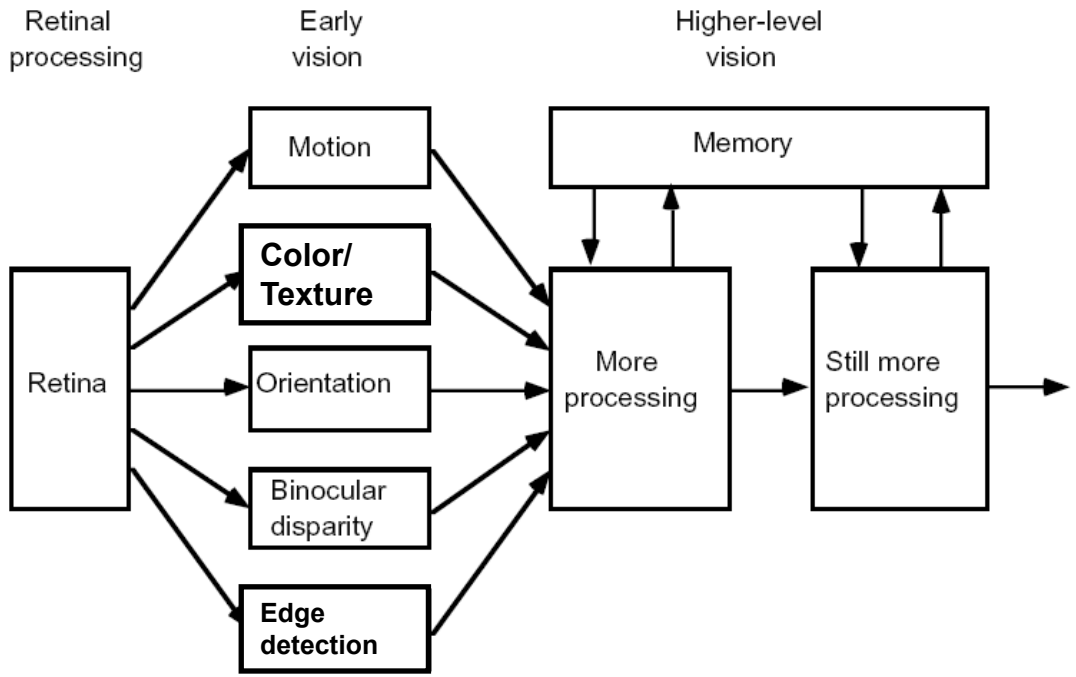
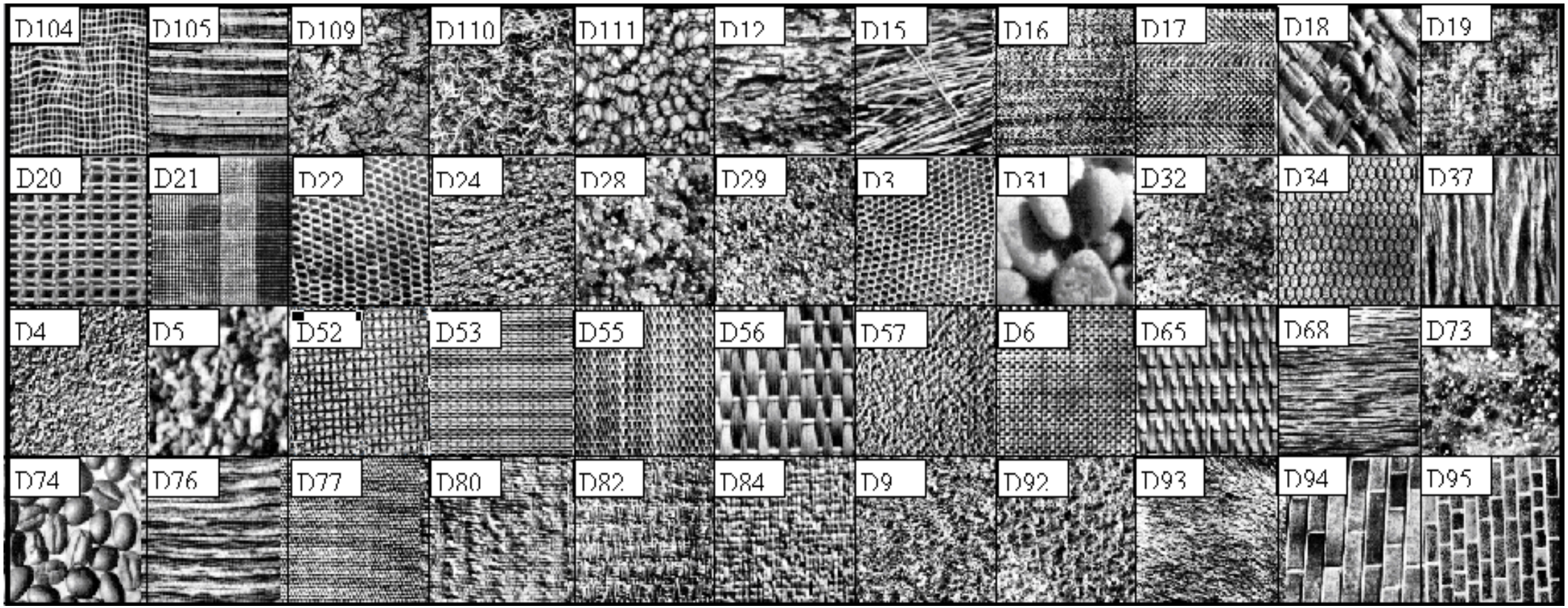


Fig. 1.1
A generic diagram for visual processing. In this approach, early vision consists of a set of parallel pathways, each analyzing some particular aspect of the visual stimulus.

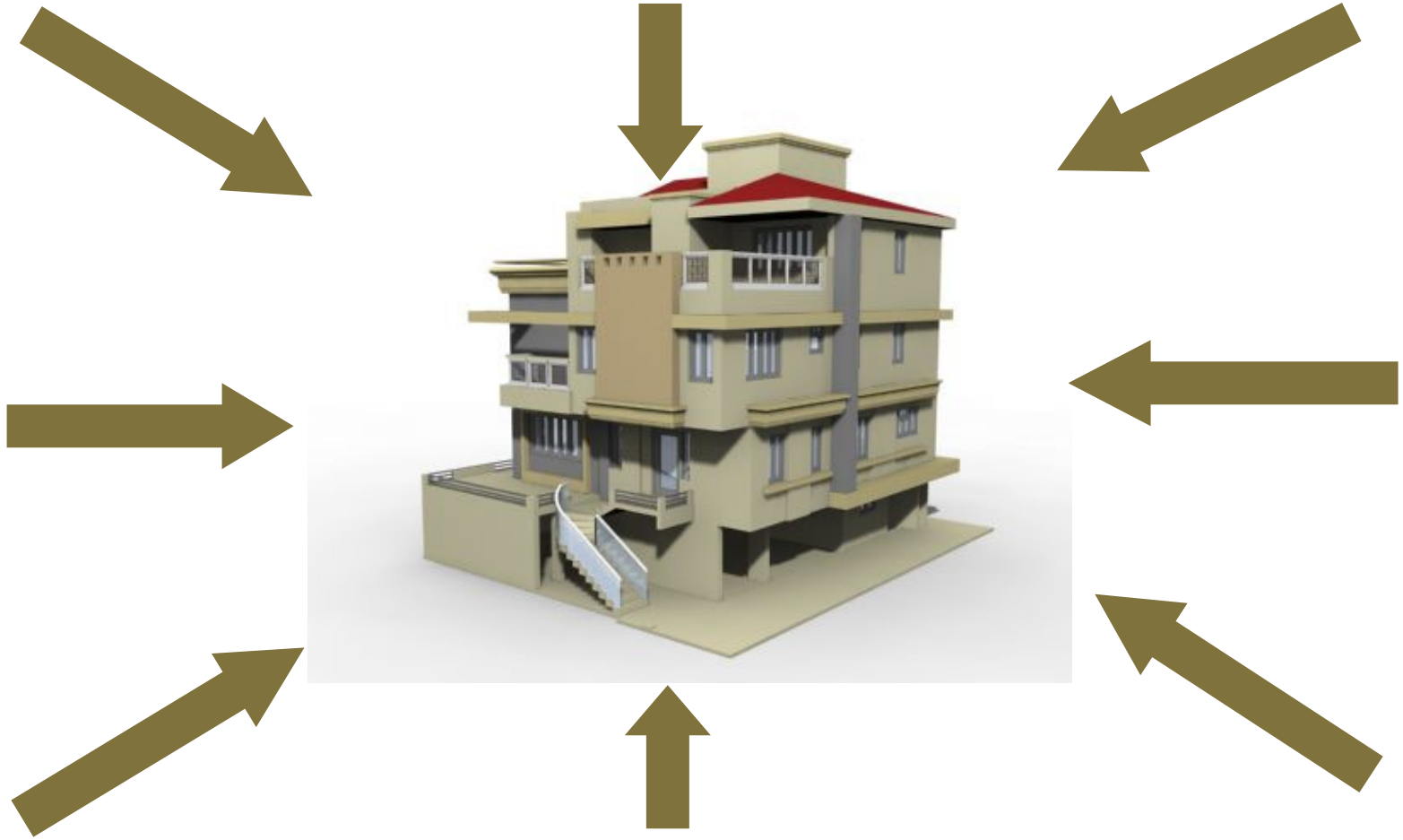
Introduction to Texture
(Deterministic/Statistical/Mixed)

Texture is a phenomenon that is widespread, easy to recognize and hard to define.



http://www.ux.uis.no/~tranden/brodatz.html

How to understand a complex object?



Filter Banks for Texture Representation

How to represent image textures more precisely?

- Convolving an image with a linear filter yields a representation of the image on a different basis, making the local structure of the image clear.
- There is a strong response when the image pattern in a neighborhood looks similar to the filter kernel, and a weak response when it doesn't.

This suggests representing image textures in terms of the responses of a collection of filters.

- The collection of different filters would consist of a series of patterns (such as spots, bars).
- While this representation is heavily redundant, it exposes structures in a way that has proven helpful.

Spots and Bars by Weighted Sums of Gaussians

By analogy with the human visual cortex, it is usual to use some ***spot filters*** and a collection of oriented ***bar filters*** at different *orientations*, *scales*, and *phases*.

These filters can be approximated by a set of Gaussian functions with different means and variances.

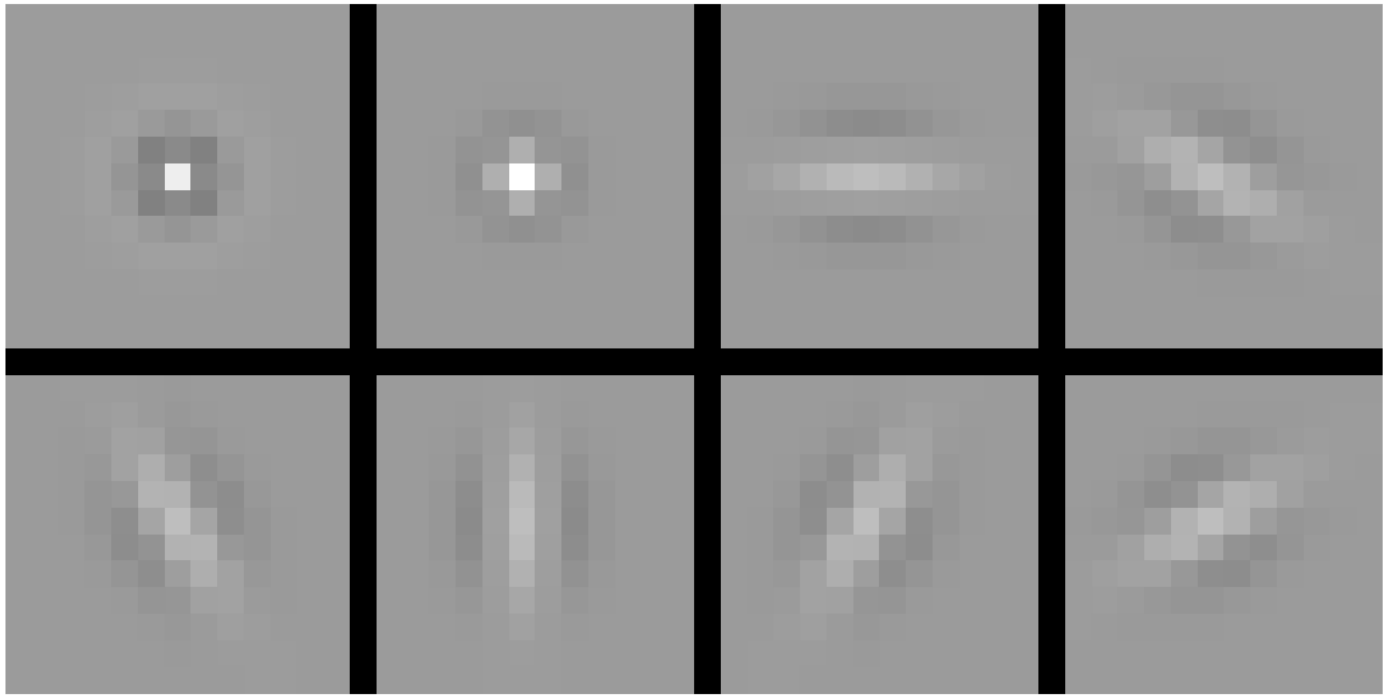


Figure 11.3. A set of eight filters used for expanding images into a series of responses. These filters are shown at a fixed scale, with zero represented by a mid-grey level, lighter values being positive and darker values being negative. They represent two distinct spots, and six bars; the set of filters is that used by [Malik and Perona, 1990].

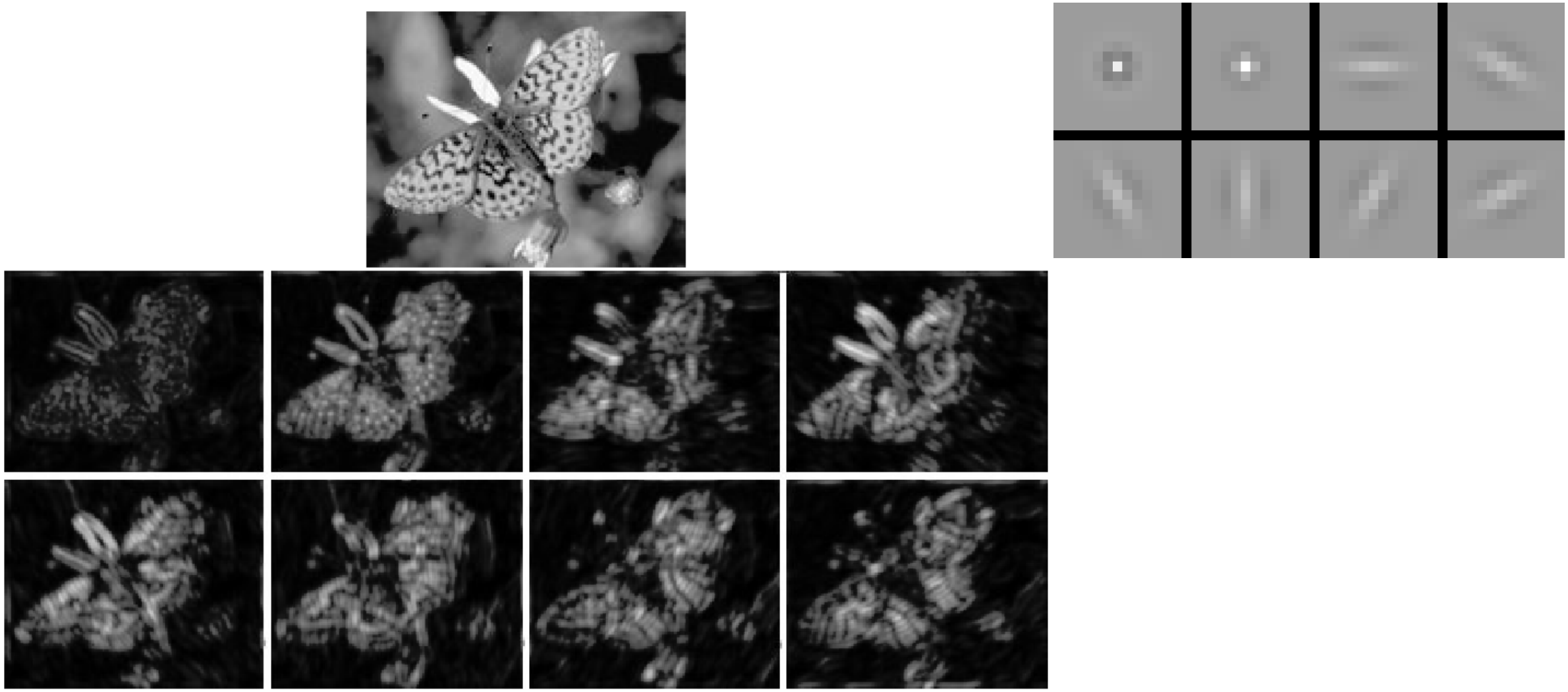
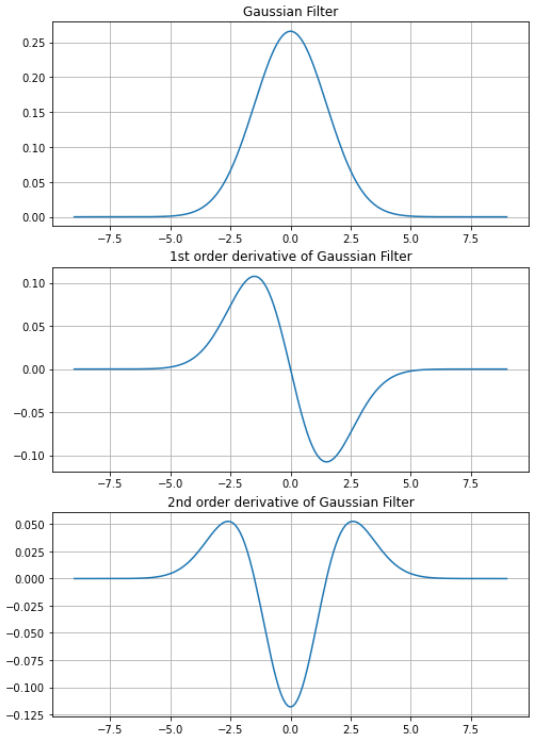
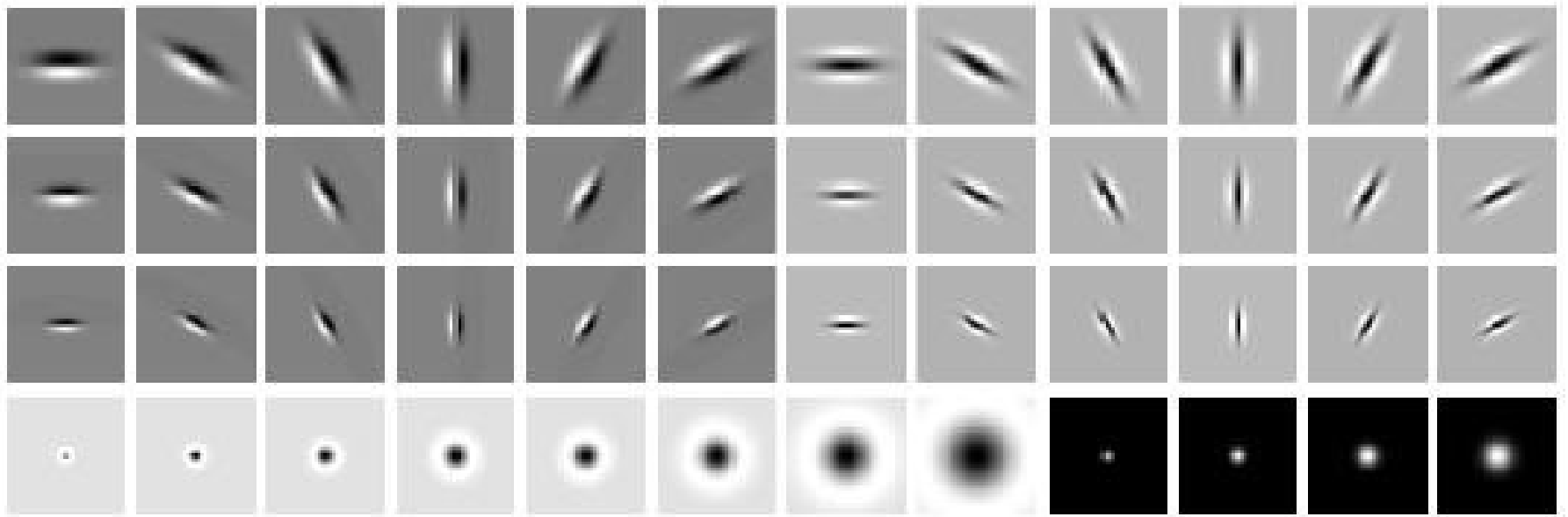


Figure 11.4. At the top, an image of a butterfly at a fine scale, and below, the result of applying each of the filters of figure 11.3 to that image. The results are shown as absolute values of the output, lighter pixels representing stronger responses, and the images are laid out corresponding to the filter position in the top row.

Filter Bank Examples for Texture Analysis: Leung-Malik (LM) Filter Bank

First and second derivatives of Gaussians at 6 orientations and 3 scales making a total of 36





8 LoG filters 4 Gaussians

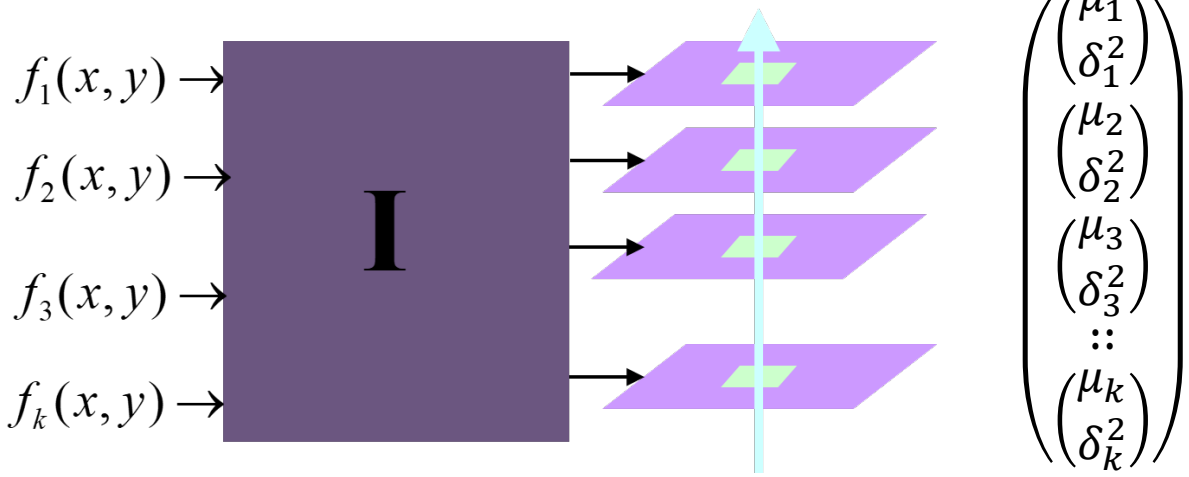
T. Leung and J. Malik. Representing and recognizing the visual appearance of materials using three-dimensional textons. International Journal of Computer Vision, 43(1):29-44, June 2001.

(1) Statistics of Filtering Output

How to characterize the filter output?

- A typical representation involves a set of statistics (e.g., mean and variance) of filter outputs for in a window given the PDF $p(x)$.

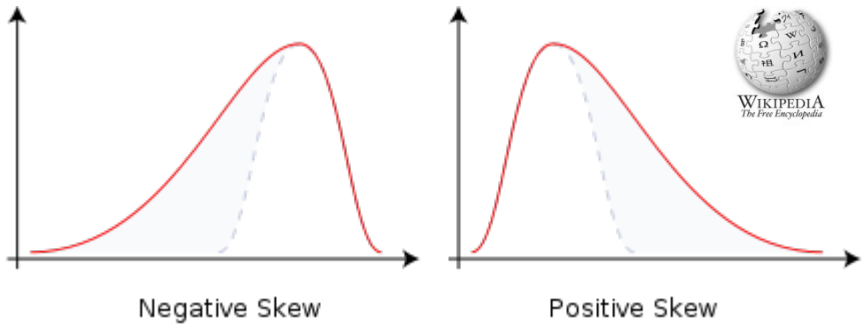
$$\mu = \int xp(x)dx : \text{mean} \qquad \delta^2 = \int (x-\mu)^2 p(x)dx : \text{variance}$$



High-order Statistics

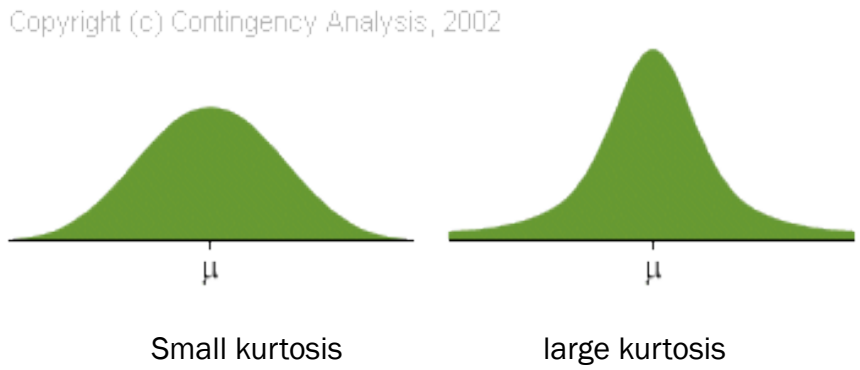
Skewness (3rd order central moment) is a measure of the *asymmetry* of the probability distribution of a variable.

$$\gamma_s = \int \left(\frac{x-\mu}{\delta}\right)^3 p(x)dx$$



Kurtosis (4th order central moment) is the degree of peakedness or flatness of the probability distribution of variable.

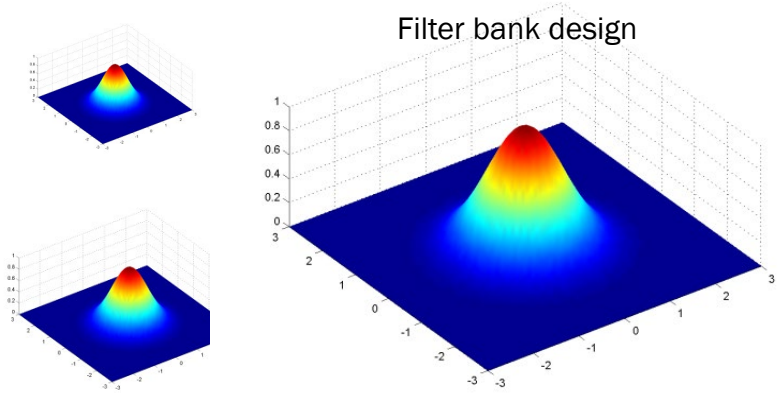
$$\gamma_2 = \int \left(\frac{x-\mu}{\delta}\right)^4 p(x)dx$$



(2) Scales for Texture Analysis

Two scales are involved for texture analysis using filter bank:

- Filter scales are related to the texture structure.
  - Filters of smaller scales are sensitive to local details
  - Filter of larger scales capture regional texture behaviors.



- Texture scales determine the window size of for computing statistics .
  - Small windows offer good spatial resolution
  - Large ones support good robustness.