• If we apply an appropriate smoothing (low-pass) filter to an image, we remove fine details (the high-frequency content) from the image

• There are 2 major reasons to do this:
  – to facilitate analysis of the coarser (low-frequency) image content
  – to satisfy the Nyquist criterion, so that the image can be subsampled without causing aliasing
Coarse-to-fine processing:

- Begin processing with an image that contains only very low spatial frequencies
- Continue processing, using images with increasingly higher resolution
- For each successive level, use results obtained at the previous level to guide analysis

Why is the multiresolution approach useful?
- Images usually contain features of physically significant structure at different scales of resolution
- For some problems, this allows us to select a desired level of detail
- For some problems, the coarse-to-fine approach can reduce the computational complexity
- There is strong evidence that the human visual system processes information in multiresolution fashion

Another motivation:
- Image compression
Pyramid representations

- An image pyramid is formed by repeated smoothing and subsampling of an image

("Subsample" = discard pixels)

- Very common:
  - Gaussian pyramid
  - Laplacian pyramid
    (Burt and Adelson, 1983)
• Each new level of a Gaussian pyramid is formed from the previous level by smoothing and subsampling:

\[ g_k(i, j) = \sum_{m=-2}^{2} \sum_{n=-2}^{2} w(m, n) g_{k-1}(2i-m, 2j-n) \]

• Conceptually, this is written as \( g_k = \text{REDUCE}(g_{k-1}) \)

• Commonly, the filter \( w \) is chosen to be symmetric, normalized, separable, and unimodal (to resemble a Gaussian function)

\[
 w = [c \ b \ a \ b \ c]^T \ast [c \ b \ a \ b \ c]
\]

E.g., \( a = 3/8, b = 1/4, c = 1/16 \)