Textons

Malik&Belongie ICCV1999, Leung&Malik, IJCV 2001, Nava&Kybic

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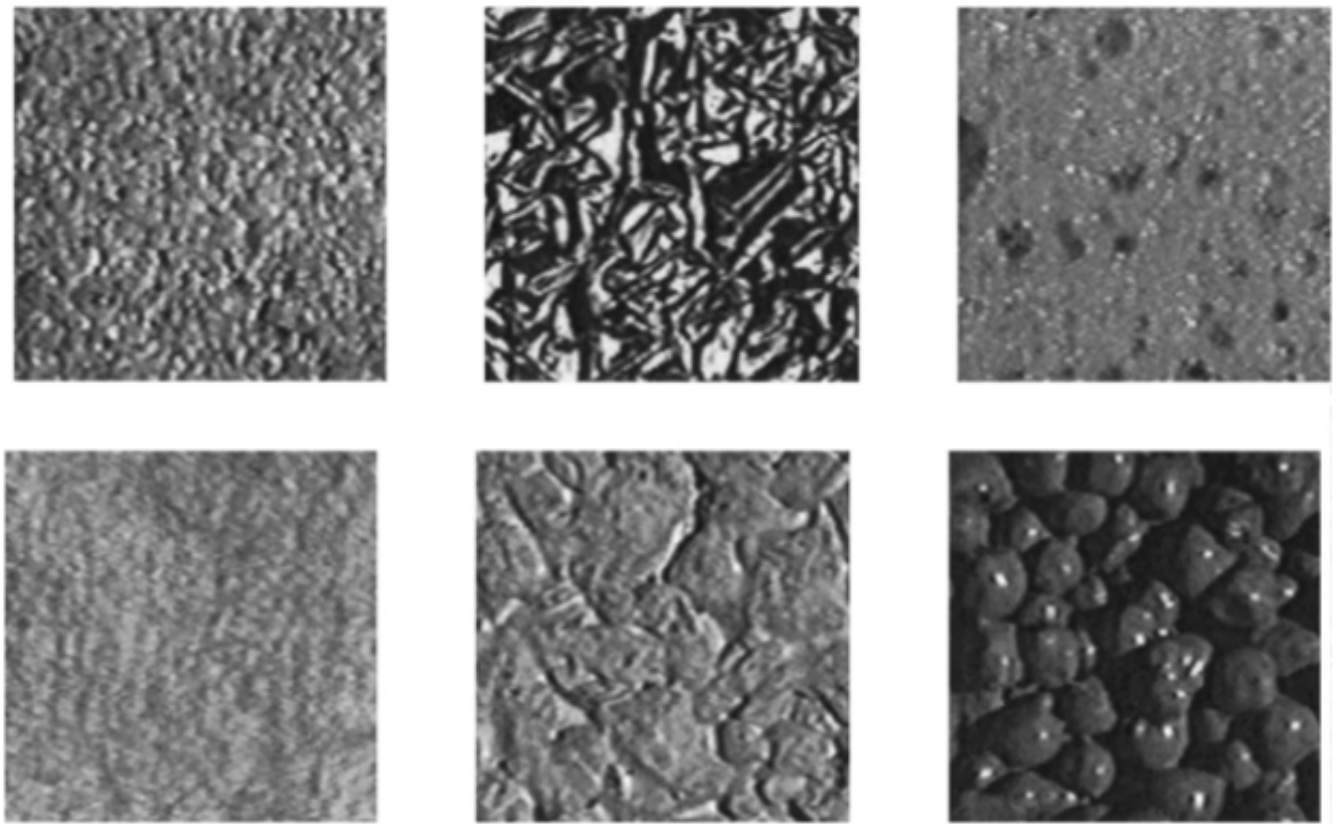
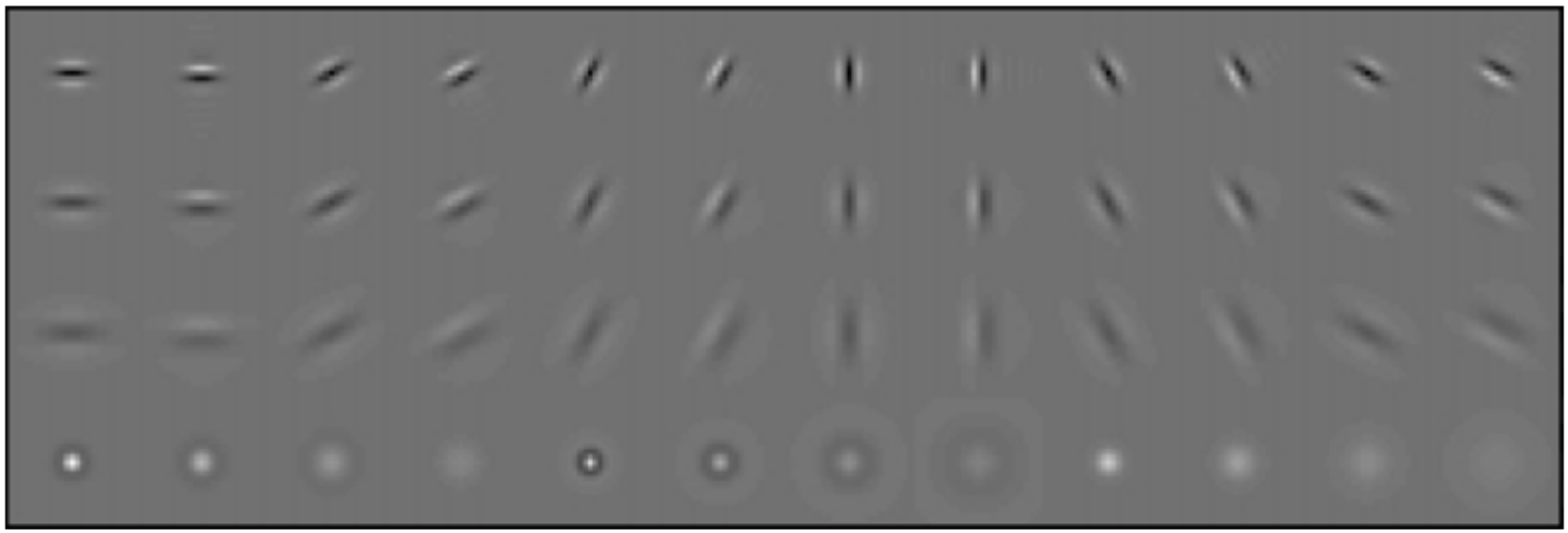
Textons

- Extract patches
- Build a dictionary of patches (textons) by k-means clustering
- Characterize new textures using this dictionary
- Originally 2D, extended to 3D

Natural textures



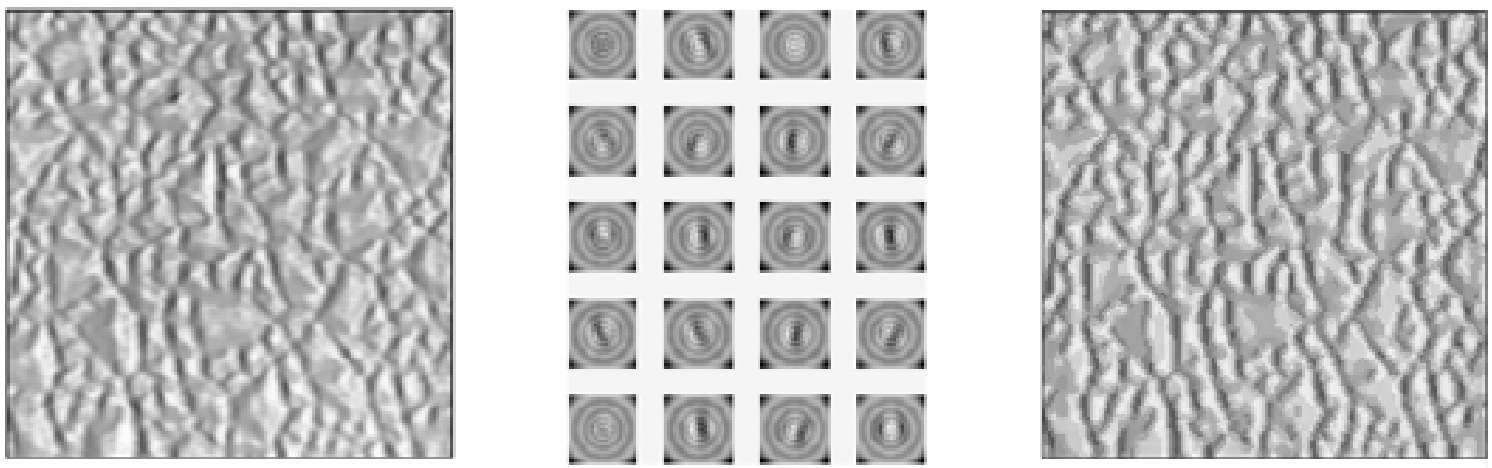
Filterbank



- 48 filters: 36 oriented filters, with 6 orientations, 3 scales, and 2 phases, 8 center-surround derivative filters and 4 low-pass Gaussian filters, DoG, normalized, size 3-28 pixels

Descriptors

- descriptors $d_i = \tilde{g}_i * f$, $d_i(x) = \langle g_i(t-x), f \rangle$, $\boldsymbol{d(x) = Gf(x)}$
- k-means clustering of $\boldsymbol{d(x)} \rightarrow$ *appearance vectors* $\boldsymbol{c_k}$
- quantize $\boldsymbol{d}$using $\boldsymbol{c_k}$- one $\boldsymbol{c_k}$ per pixel. Texton *channels*.
- reconstruct $\boldsymbol{f \approx G^+ d_k \approx G^+ c_k}$, $\boldsymbol{G^+ = (G^T G)^{-1} G}$, or SVD

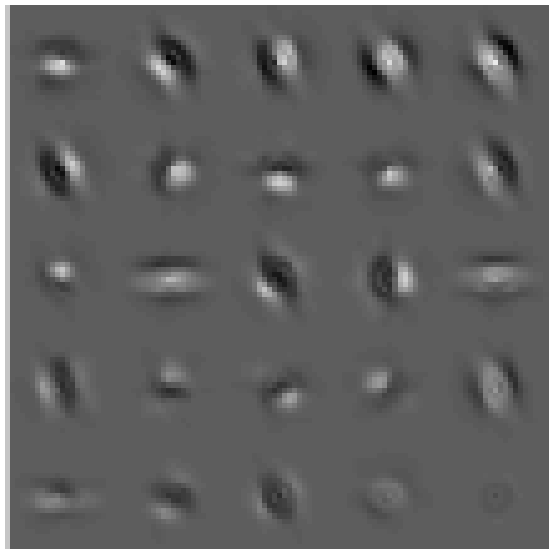


original, textons, reconstruction

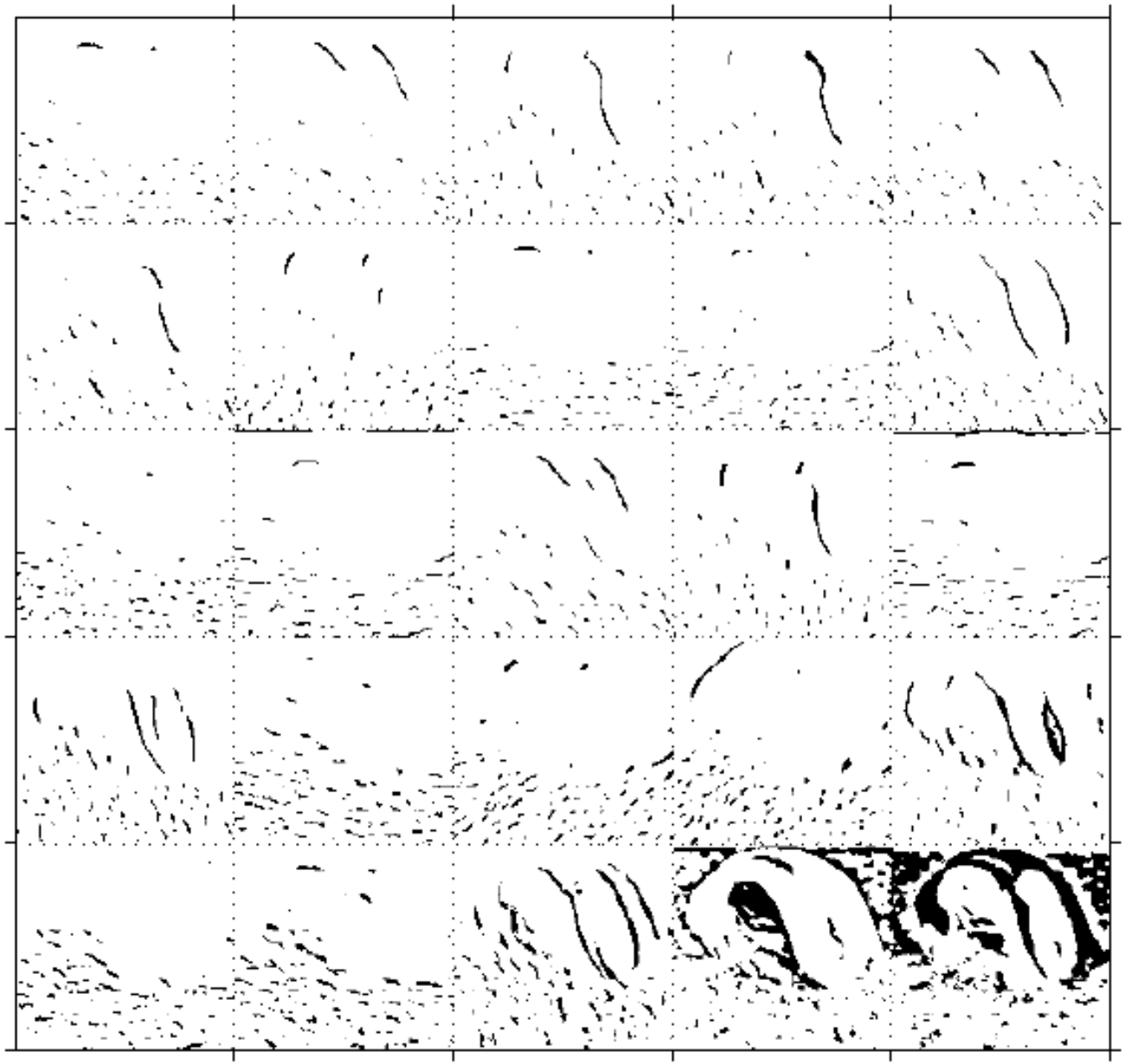
Texton example

(a)

(b)



Texton decomposition



Texton segmentation

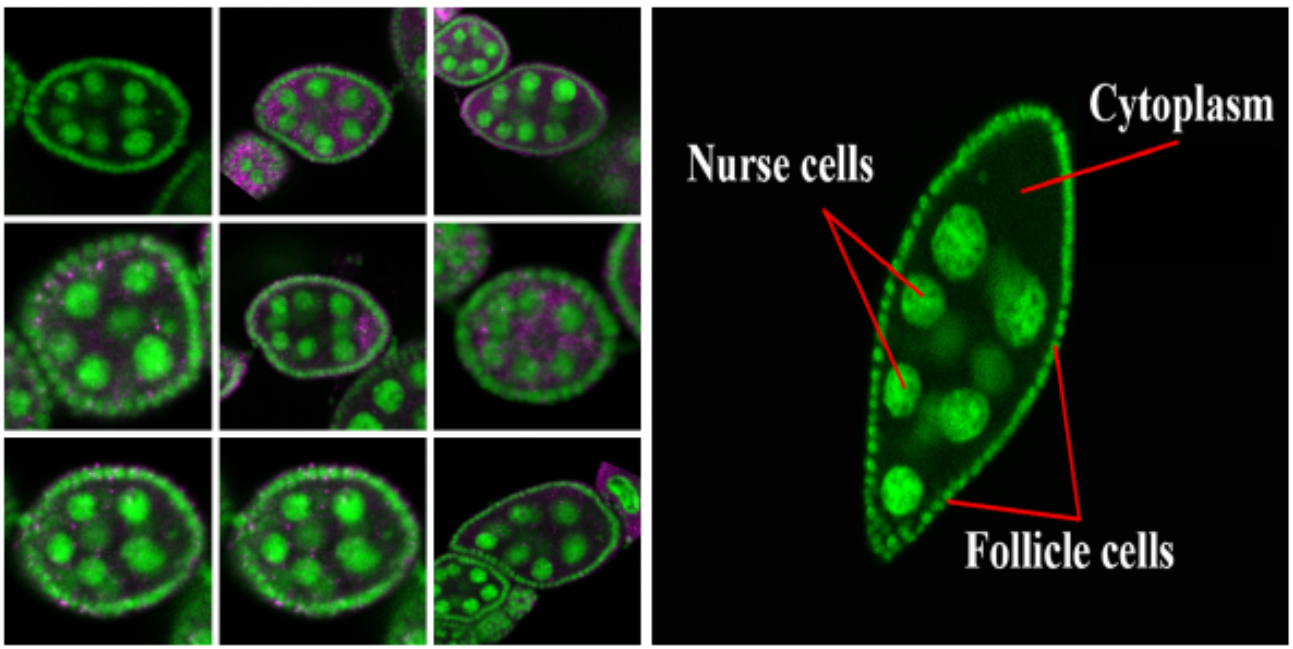
- Texton histogram in a local neighborhood $\rightarrow$
  - measuring texture similarity

$$\chi^2(h_i, h_j) = \frac{1}{2} \sum_{k=1}^{K} \frac{[h_i(k) - h_j(k)]^2}{h_i(k) + h_j(k)}$$

  - descriptor to classify textures
- other cues - contours...

Example - Drosophila segmentation

Nava, Kybic, ICIP2015



Supertextons

- SLIC superpixels
- 18 filters: max over 6 orientations (for invariance) of 3 scales of 1^{st}+2^{nd}DoG, plus 8 LoG, 4 Gaussians

Let $I(x, y)$ be an input image and given a filter bank, LM_{18}, then the responses F_i are computed as follows:

$$F_i = I(x, y) \star LM_i \tag{1}$$

where $\star$ is the convolution.

For each labeled superpixel in the corresponding $T(x, y)$ the following features are computed:

- Mean: $\mu_i = \frac{1}{N_I} \sum I_{F_i}$, where I_{F_i} are the intensity values $\in F_i$ within the corresponding superpixel region and N_I the number of intensity values.
- Standard deviation: $\sigma_i = \sqrt{\frac{1}{N_I} \sum (I_{F_i} - \mu_i)^2}$
- Energy: $E_i = \frac{1}{N_I} \sum (I_{F_i})^2$
- Average gradient: $G_i = \sum \|\nabla I_{F_i}\|$

Supertextons (2)

We included a normalization process to transform the feature vectors x to a random variable normally distributed [13]

$$\tilde{x} = \frac{x - \mu_x}{2\,(3\sigma_x + 1)} \tag{2}$$

where m_x and σ_x are the mean and standard deviation of the feature vector, respectively.

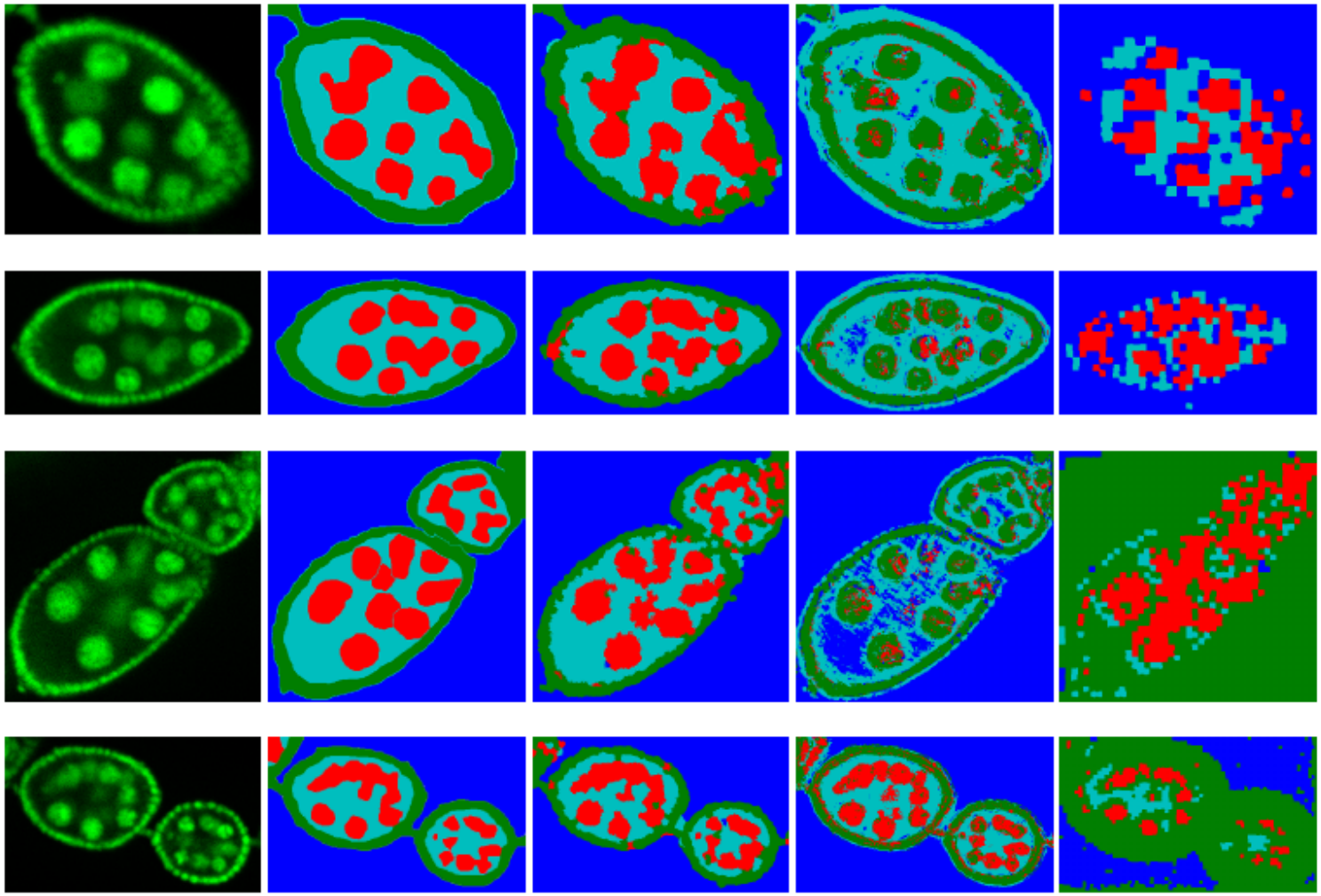
Hence, the rescaled feature vectors are built as follows:

$$\overline{f} = \left[\tilde{\mu_1}, \tilde{\sigma_1}, \tilde{E_1}, \tilde{G_1}, \ldots, \tilde{\mu_L}, \tilde{\sigma_L}, \tilde{E_L}, \tilde{G_L}\right] \tag{3}$$

where L corresponds to the L-th filter response.

- k-means clustering for each class, k=0,1.. N
- Classification by k-NN (k=6)
- outperforms pixel-based segmentation and textons

Segmentation results



original, ground truth, supertextons, pixel-based, textons