Computational Image Classification in Cell Biology

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Goals

Overall: To extract a set of geometric and non-geometric subcellular features from images of cells stained for components (Focal Adhesions) that are responsive to the mechanical properties of the surface Extra Cellular Matrix (ECM), and to discover the relationships that exist between them. This will lead to better understanding of how cells process mechanical stimuli and impact development.

Statistical Goal: Quantify the range of feature characteristics under different mechanical conditions and generate a classifier to analyze unknown cell structures.

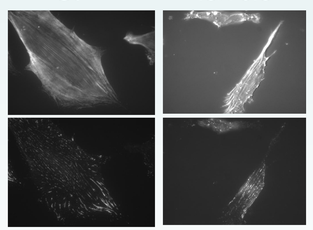
Motivation (Why should I spend time on this?)

- **Traditional Cell Classification (Manual)**
  - Finding objects of interest by observation
  - Bias and Variable Image Quality
- **Responses of cells to altered ECM are highly relevant to cancer and stem cell research**

Collagen (ECM) → Stiff Flexible

Actin stress fibers

Focal Adhesions



Related Work(Stops us from reinventing the wheel)

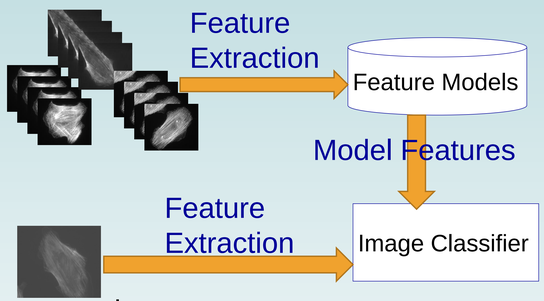
- **Cervical Cell Classification using Gray Level Co-occurance Matrix and Linear Discriminant Analysis**
- **Binary Histogram in Image Classification for Retrieval purposes.**

Method(How will I approach the problem)

Overview

- Categorize a raster cell image into a finite set of classes.
- Convert raster data into feature vectors.
- Support vector machine image classifier.
- Metadata to map specific classes to biological characteristics.

- We obtained a set of cell images from the A10 cell line, stained with an antibody for the focal Adhesions



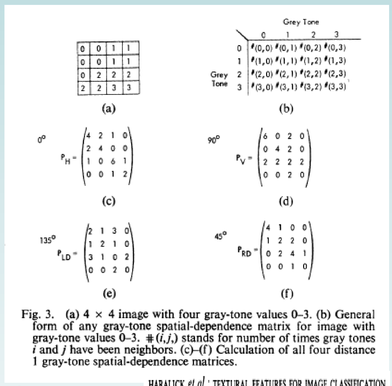


Fig. 3. (a) 4 × 4 image with four gray-tone values 0–3. (b) General form of any gray-tone spatial-dependence matrix for image with gray-tone values 0–3. #(i,j) stands for number of times gray tones i and j have been neighbors. (c)–(f) Calculation of all four distance 1 gray-tone spatial-dependence matrices.

HARALICK *et al.*: TEXTURAL FEATURES FOR IMAGE CLASSIFICATION

Spectral image features (color/tone).

- Histogram (color, binary,gray).
- Distribution, size, width, mean, standard deviation.

Textural image features (spatial distribution).

- Gray-level co-occurrence matrix (GLCM).

GLCM (P) is the estimate of joint PDF of gray level pairs in an image

- **Energy:**

$$Energy = \sum_{i,j} \mathbf{P}(i,j)^2;$$

- **Correlation:**

$$Correlation = -\sum_{i,j} \frac{(i-\mu_x)(j-\mu_y)}{\sqrt{(\sigma_x \sigma_y)}} \mathbf{P}(i,j)$$

- **Entropy:**

$$Entropy = -\sum_{i,j} \mathbf{P}(i,j) \log \mathbf{P}(i,j);$$

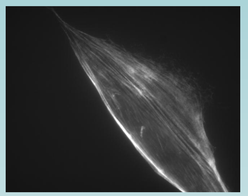
- **Inertia:**

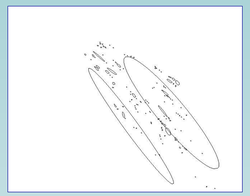
$$Inertia = \sum_{i,j} (i-j)^2 \mathbf{P}(i,j)$$

Toolset (What comes to my aid)

- **ImageJ**

  We can use an elliptical fit algorithm to quantify the distribution, order, and orientation of the actin fibers





- **SVM light**
- **BioWeka**

System Evaluation (Am I on right track?) and Result

Use Leave-one-out technique to test our ability to classify unknown images against a set of known image features, and compute sensitivity (true positives / true positives + false negatives), specificity (true negatives / true negatives + false positives), and accuracy to test our generated model.

Future Work

- **Metadata Repository**

  I would like to develop a metadata repository for the analyzed cells. Meta data for cells will contain the analyzed spectral and textural features. The sources of image data will be documented along with the actual metadata of images

References

•Arzhaeva Y, Ginneken BV, T. D. Tax d. image classification from generalized image distance features: application to detection of interstitial disease in chest radiographs.18th International Conference on Pattern Recognition
• Elis R, A. C. Computational imaging in cell biology. The Journal of Cell Biology 161, 3 (2003), 477 – 481.
• Kunttu1 I, LepistÃu1 L, R. J. V. A. Binary histogram in image classification for retrieval purposes. Journal of WSCG 11, 1 (2003), 269 – 273.
• W. Matthew Petroll, L. M. Direct, dynamic assessment of cell-matrix interactions inside fibrillar collagen lattices. Cell Motility and the Cytoskeleton 55, 4 (march. 2003), 254 – 264.
• Haralick, R. M., Shanmugam, K., and Dinstein, I. Textural features for image classification. Systems, Man and Cybernetics, IEEE Transactions on 3, 6 (nov. 1973), 610 – 621.