Comparison of Texture Segmentation Algorithms for Electron Microscopy

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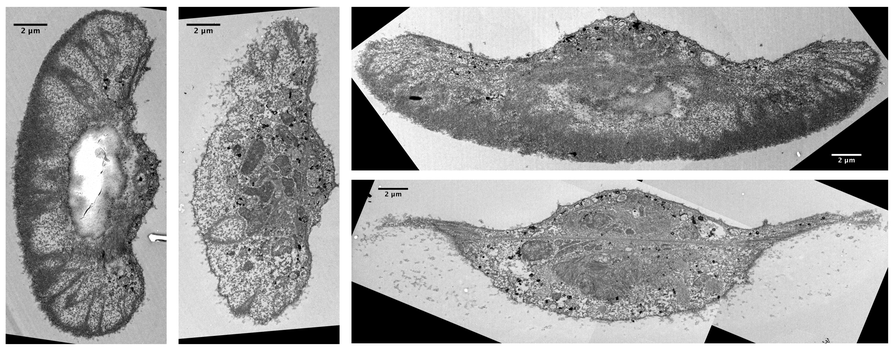
Motivation

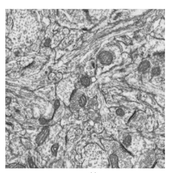
Segmentation is a major bottleneck in electron microscopy image processing.

Challenge: features of interest differ in *texture* rather than *intensity*.

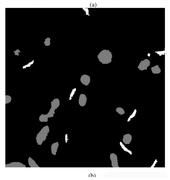
Texture-based segmentation algorithms would be significantly faster and more reproducible than current manual segmentation approaches.



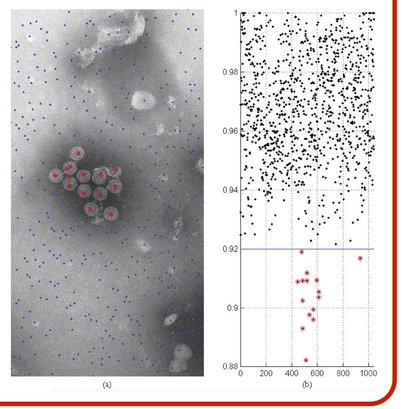
Related Work



- Combination of Gabor filters and Local Binary Pattern to segment organelles (Gorai A. 2014 doi: 10.1109/PDGC.2014.7030719)



- Image entropy, contrast, and variance filters used to identify virus particles (very stereotyped shape) (Proenca M. et al 2013 doi: 10.1017/S1431927613001736)



Three Different Segmentation Strategies

1. Local Thresholding and Morphology

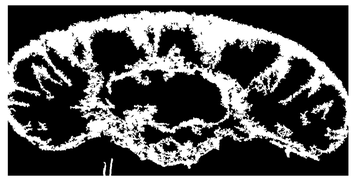
- Adaptive thresholding
- Opening and closing
- Small region removal

2. Local Binary Pattern (LBP) (Ahonen T et al 2006 doi: 10.1109/TPAMI.2006.244)

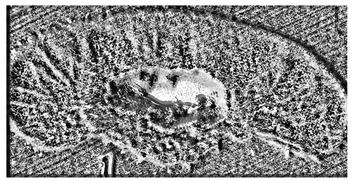
- Local grayscale correlation metric
- Features are histograms of sliding windows
- Use SVM to learn different textures

3. Local Spectral Histograms (LSH) (Yuan J. et al. 2012 doi:10.1016/j.patrec.2011.12.003)

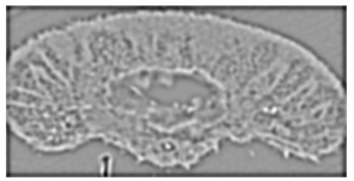
- Compute a filter bank: Gabor and LoG filters
- Features are concatenated histogram from all filters, in a sliding window
- Use "integral histogram" to compute efficiently
- Use SVM to classify different feature vectors



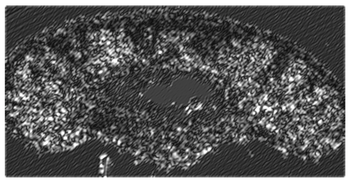
Thresholding



LBP



LoG

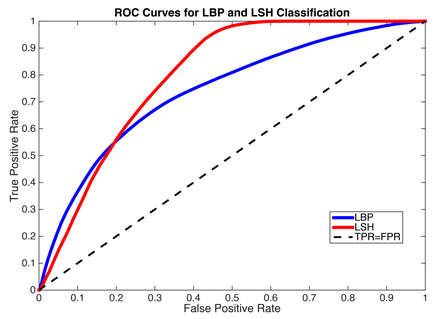


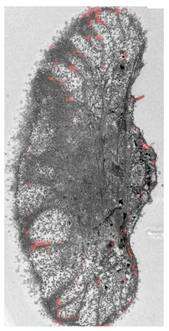
Gabor

Experimental Results

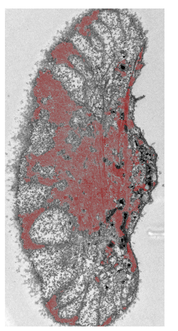
Method	Precision TP/(TP+FP)	Recall TP/(TP+FN)	Jaccard TP/(TP+FP+FN)
Threshold	38%	73%	33%
LBP	46%	7%	7%
LSH	34%	47%	25%

Surprisingly, the most naïve algorithm (thresholding) performed the best. The threshold method had very high recall, i.e. identified most of the ground truth pixels (and many more as well). Exploratory analysis suggests the main reason for the failure of the more sophisticated methods is that the feature vectors were not well separated enough for simple SVM to work. More robust machine learning approaches may be required, as well as further optimization of features, e.g. filter sets, window sizes, etc.

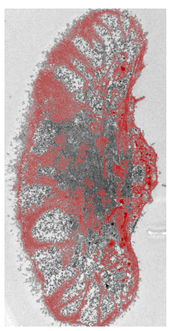




LBP



LSH



Threshold