Automated analysis of microscopic images of cellular tissues

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December 8, 2017

Overview

- The problem

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- The problem
- Initial impressions

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  - Watershed segmentation
  - Local extrema
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- Conclusion

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i.e. we want to determine cell statistics.

Why is this a problem?

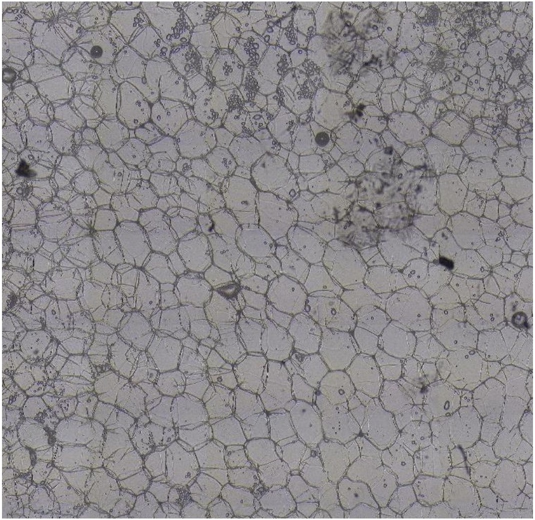

Figure 1: An example of a microscope image. Note that here the best area of a larger image is selected.

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- Work with a Fourier transformed image, in Frequency Space

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Watershed segmentation

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Now we have found various segments in the image.

Literature results

We look at [2] which uses the Ultrametric Contour Map (UCM) from [3]. An example:

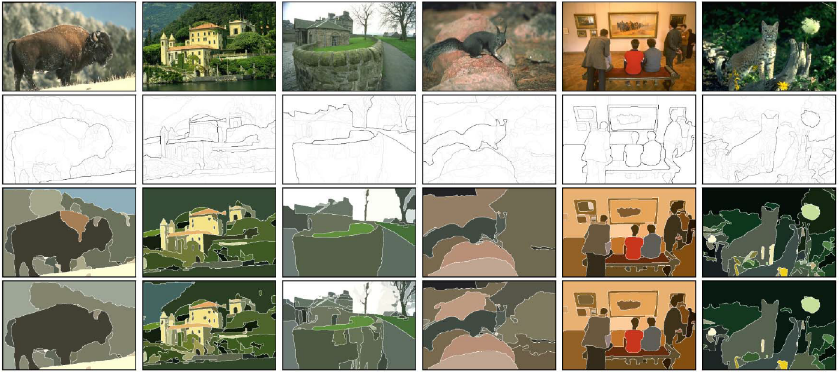


Figure 2: Examples of segmentation by UCM. From top to bottom: Image, UCM produced by gPb-owt-ucm, and ODS and OIS segmentations, source [3].

Literature results cont'd

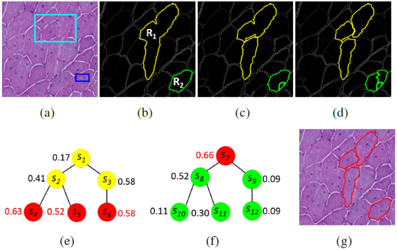
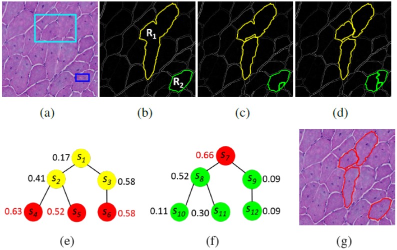


Figure 3: Decision tree for the segmentation using the UCM, source [2].

Literature results cont'd



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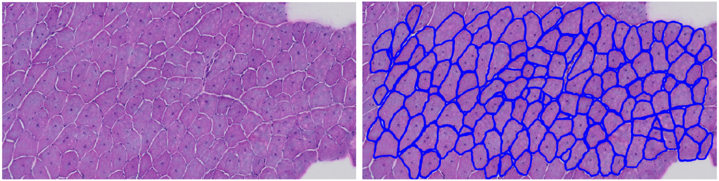

Figure 4: Segmentation results, source [2].

Contrast enhancement

$$f_{\text{out}}(x, y) = \frac{1}{1 + e^{4m[f_{\text{avg}}(x,y) - f_{\text{in}}(x,y)]}} \tag{1}$$

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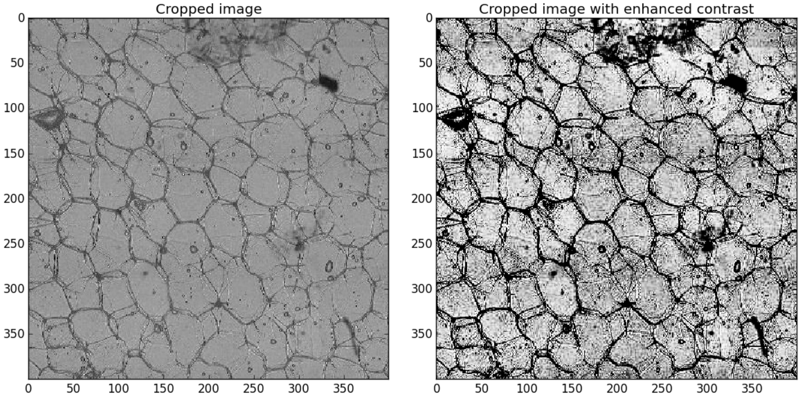

Figure 5: Left just a cropped image from Fig. 1. On the right the image, with locally enhanced contrast. We have $m = 10$ and a radius r of 50 pixels.

Our results

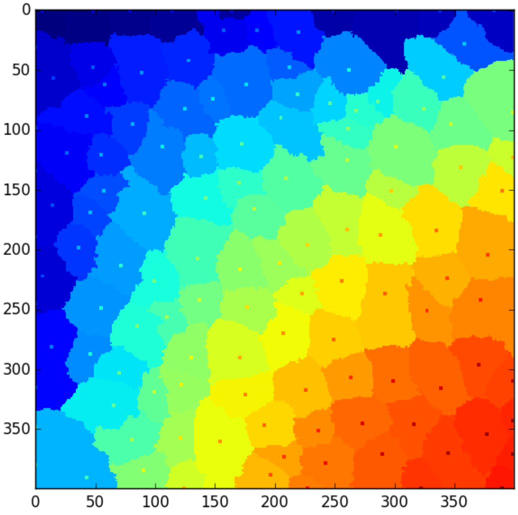

Figure 6: Our result for a watershed segmentation.

Local extrema

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Locate local maxima or minima on the image.

Transformed image

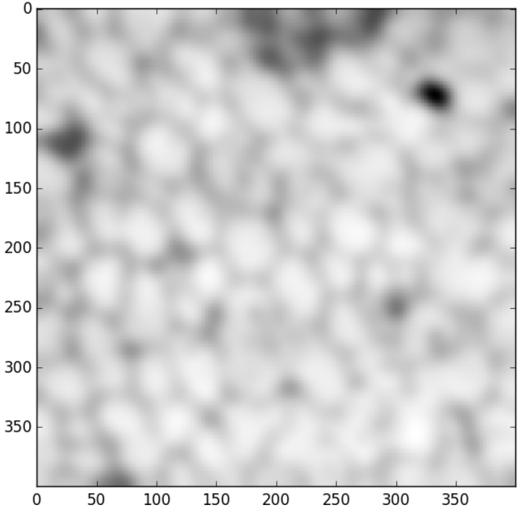

Figure 7: A transformed image, here we have used a Gaussian with $\sigma = 7$.

Distinguishability of peaks

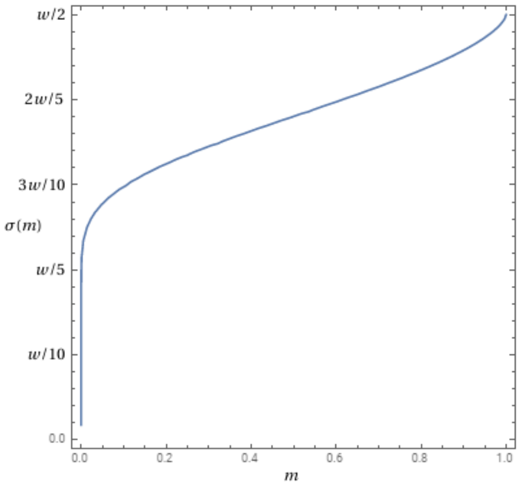

Figure 8: A numerical solution to the merging of two Gaussian peaks. w is the distance between peaks, m the ratio in amplitude and σ the standard deviation of the Gaussian. Also read [5, 6].

Choosing σ

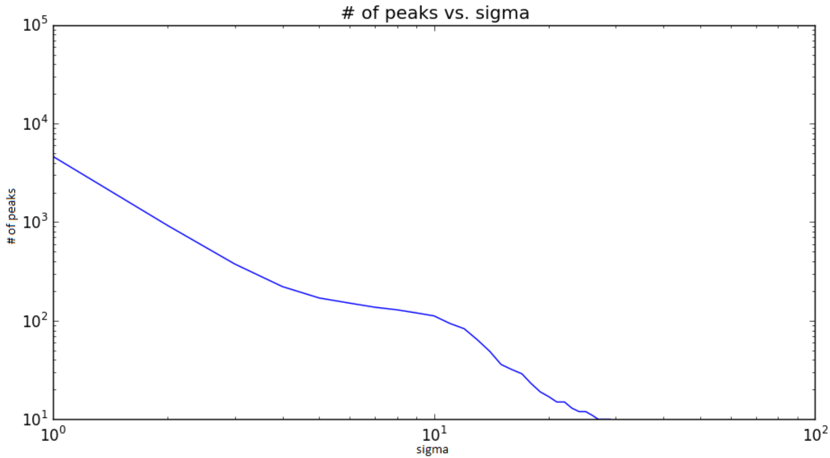

Figure 9: Here we study the number of detected peaks vs. the standard deviation σ. We choose the value $\sigma = 7$.

Choosing σ cont'd

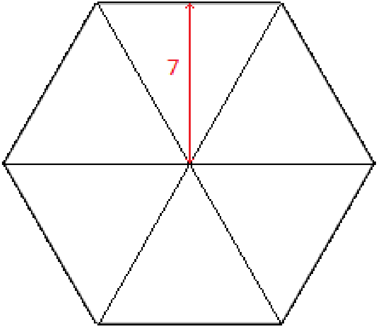

Figure 10: Using simple geometry we can determine a suitable σ for finding minima. This turns out to be approximately 4.

Results

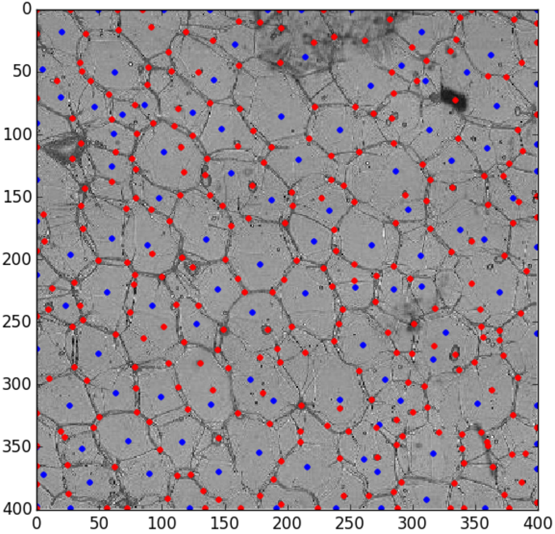

Figure 11: Local extrema. In blue the cell centres, in red the corners of the cells.

Connecting the dots

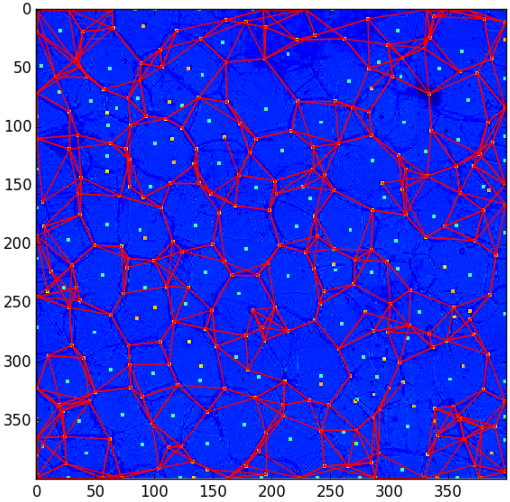

Figure 12: Connected cell corners. We see some interesting results, but it is very complicated to extract cells from this data.

Latest development

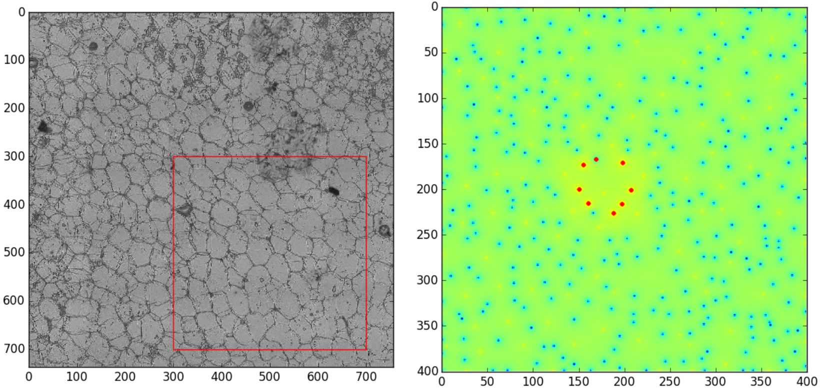

Figure 13: Located corners of an octagonal cell (as we have only allowed 8 points to move).

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- Finding local extrema as a foundation.
- Using a potential to form cells.

References I

- [1] P.J.W. Iles, *Average Cell Orientation, Eccentricity and Size Estimated from Tissue Images*, Master thesis, University of Waterloo, Waterloo, Ontario, Canada, (2005).
- [2] F. Liu, F. Xing & L. Yang, *Robust Muscle Cell Segmentation using Region Selection with Dynamic Programming*, Proceedings IEEE int. Symp. Biomed. Imag., pp. 521, April (2014).
- [3] P. Arbelez, M. Maire, C. Fowlkess & J. Malik, *Contour Detection and Hierarchical Image Segmentation*, IEEE transactions on pattern analysis and machine intelligence, vol. 33, no. 5, 898, (2011).
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[5] K. de Clerk & T.S. Buys, *Analytical efficiency in chromatography. I. Qualitative efficiency*, Separation science, vol. 7, no. 4, pp. 371-387, (1972).

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