Automated analysis of microscopic images of cellular tissues

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Overview

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  - Current Development
- Conclusion
Microscope images of potato slices.

The problem

Important features: Individual cells.

▶ Average size.
▶ Average eccentricity.
▶ Orientation.

Beyond that we also want to know the variation.

▶ Cell wall thickness.

i.e. we want to determine cell statistics.
The problem

Microscope images of potato slices. Important features: Individual cells.
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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.
Some first impressions

We have:

- Brightness of the pixels.
- We can see the cells with our own eyes.

Two main options:
- Work with the real image, which we call Real Space.
- Work with a Fourier transformed image, in Frequency Space.
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How does the watershed method work?

- Locate drainage points.
- Let 'water' flow into the lowest areas. (i.e. the darkest pixels.)
- When the image is filled stop.

Now we have found various segments in the image.
Watershed segmentation

How does the watershed method work?

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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].
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

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

How to find cell centres?
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Convolve the image with a Gaussian peak, i.e. use a Weierstraß transformation.
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Locate local maxima or minima on the image.
Figure 7: A transformed image, here we have used a Gaussian with $\sigma = 7$. 
Figure 8: A numerical solution to the merging of two Gaussian peaks. \( w \) is the distance between peaks, \( m \) the ratio in amplitude and \( \sigma \) the standard deviation of the Gaussian. Also read [5, 6].
Choosing $\sigma$

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

![Graph showing the number of peaks vs. $\sigma$.](image)
Choosing $\sigma$ cont’d

Figure 10: Using simple geometry we can determine a suitable $\sigma$ for finding minima. This turns out to be approximately 4.
Figure 11: Local extrema. In blue the cell centres, in red the corners of the cells.
Figure 12: Connected cell corners. We see some interesting results, but it is very complicated to extract cells from this data.
Figure 13: Located corners of an octagonal cell (as we have only allowed 8 points to move).
Conclusion

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- Finding local extrema as a foundation.
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- Identification of the problem.
- Attempts at a simple solution don’t work.
- Finding local extrema as a foundation.
- Using a potential to form cells.
References I


