# Cell Segmentation Using Image Processing Methods

Xénia Richnáková
*Supervised by: Jiří Hladůvka*

Faculty of Mathematics, Physics and Informatics Comenius University Bratislava / Slovakia

## Abstract

Reliable instance segmentation is a key prerequisite for cell counting and quantitative analysis in brightfield microscopy, where low contrast, halos, and clustered cells often break simple thresholding. This work proposes a training-free pipeline that combines a distance-transform seeded watershed [1] for the initial partitioning with a convexity-defect-based [2] post-processing step to separate touching cells. For each candidate cell region, deep concavities of the contour are detected via convexity defects and used to place a cut line between the strongest defect points, yielding a refined instance mask. Segmentation success is evaluated by IoU-based instance matching against ground-truth masks (IoU≥0.5), reporting precision/recall, F1 and a panoptic-quality-style score [5].

**Keywords:** cell segmentation, image processing, watershed, microscopy, cell counting

## 1 Method

The pipeline starts with grayscale normalization and Gaussian smoothing [7], followed by adaptive thresholding [6] and morphology to obtain a clean binary mask of cell material. To create watershed markers, a smoothed Euclidean distance transform [3] is computed inside the binary mask, and local maxima are extracted with a minimum-separation constraint. Watershed is applied on a potential that combines gradient magnitude and distance information to encourage boundaries at strong intensity transitions. Touching cells that remain merged after watershed are split using convexity defects computed from the outer contour and its convex hull [4]. If at least two defects exceed a depth threshold, the two deepest defects are selected and a short cut line is drawn between their farthest points to break the merged region into separate instances. The final output is an instance-labeled image suitable for cell counting.

## 2 Evaluation

Ground-truth masks are treated as binary foreground and converted to instance labels via 8-connected component labeling. Predictions are provided as an instance-labeled mask where background is zero. Pairwise intersection-over-union (IoU) between ground-truth and predicted instances is computed, and pairs with IoU≥.5 are greedily matched. From the matches the true/false positives and negatives, precision, recall, F1@0.5, the mean IoU over matched pairs, and PQ/RQ/SQ-style summary scores are reported.

## 3 Conclusion

Convexity-defect driven splitting provides an interpretable mechanism to separate clustered cells without training data. Future work includes automating parameter selection and analyzing profile of the generated line - predicted cell boundary - for the cases when the line passes through the interior of the cell and not approximating the real boundary.

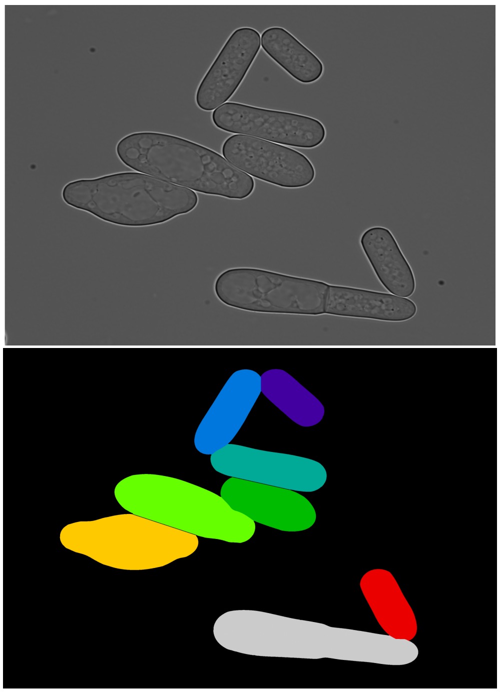

Figure 1: Original image (top) and segmentation result (bottom).

**Acknowledgments:** This work was supported by the European Union's NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project 09I03-03-V04-00363.

## References


[1] Serge Beucher and F Meyer. Segmentation: The watershed transformation. mathematical morphology in image processing. *Optical Engineering*, 34:433–481, 01 1993.

[2] G. Bradski. The OpenCV Library. *Dr. Dobb's Journal of Software Tools*, 2000.

[3] Pedro Felzenszwalb and Daniel Huttenlocher. Distance transforms of sampled functions. *Theory of Computing*, 8:415–428, 08 2004.

[4] R. Graham. An efficient algorithm for determining the convex hull of a finite planar set. *Information Processing Letters*, 1(4):132–133, 1972.

[5] Alexander Kirillov, Kaiming He, Ross Girshick, Carsten Rother, and Piotr Dollar. Panoptic segmentation. pages 9396–9405, 06 2019.

[6] W. Niblack. An introduction to image processing. In *Prentice-Hall International Series in Computer Graphics and Geometric Modeling*. Prentice-Hall, 1986. Chapter on Local Thresholding.

[7] I. T. Young and Lucas J. van Vliet. Recursive implementation of the gaussian filter. *Signal Processing*, 44(2):139–151, 1995.