## Direct Inference of Cell Positions using Lens-Free Microscopy and Deep Learning

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Computer-

image

reconstructed





- How cells move can tell us about diseases
- Our approach: Live cell imaging of possibly thousands of cells over a long period of time, extracting movement patterns
- All done with a lens-free, low-cost microscope using inline-holography
- Baseline to get positions: Captured images need to be reconstructed and the cells segmented
- We replace the baseline with a U-net

Pattern Recognition Company, Fraunhofer EMB, University of Lübeck; The authors would like to thank Mr. Fabian Bormann for inspiration

## Baseline vs. CNN

Trained on the baseline segmentations: CNNs detect similar cells as the baseline

CNN	Prec.	Rec.	F1	JI	sec
Mobilenet-V2	0.897	0.772	0.829	0.605	115
$\operatorname{ResNet-18}$	0.941	0.869	0.903	0.696	119
$\operatorname{ResNet-50}$	0.929	0.852	0.889	0.673	172
$\operatorname{ResNet-152}$	0.947	0.849	0.895	0.669	246

Trained on simulated data: CNNs yield better segmentations

Table 1: Results for the simulated data.								
CNN	Prec.	Rec.	F1	JI				
Mobilenet-V2	0.981	0.952	0.966	0.844				
ResNet-18	0.976	0.959	0.967	0.845				
ResNet-50	0.979	0.956	0.967	0.832				
ResNet-152	0.975	0.961	0.968	0.847				
Baseline	0.884	0.860	0.870	0.664				

Reconstruction Global threshold: Segmentation

Raw Data (Holograms)

We optimize this step:



Cell Tracks Statistics, Learning, ...

Reconstruction

Global threshold: CNN-based Segmentation

(Convolutional neural network) Much faster: 1/3 of the time the baseline needs

## What about the CNN's "errors"?

- A ResNet-18 with an adapted threshold is the only model with a <u>constant cell</u> <u>count</u> (most realistic outcome)
- When compared to the baseline, many of the false positive detections (FPs) look like real cells
- There is a high correlation between the baseline cell statistics and the statistics derived from our method: <u>FPs behave like cells</u>
- All this is evidence that FPs are actual cells

d threshold tant cell		.25 .50 .95	$0.921 \\ 0.941 \\ 0.684$	0.918 0.869 0.403	$0.919 \\ 0.903 \\ 0.505$	$0.724 \\ 0.696 \\ 0.324$	-0.211 -0.435 -1.231
e) eline, many ns (FPs) look	•	1000	•			•	

Thres. Prec. Rec.

.05



F1

0.845 0.900 0.871 0.622

JI

Slope

-0.039

PCC

0.989

0.989

0.988

0.974

White: True Positives, Blue: False Positives, Red: False Negatives