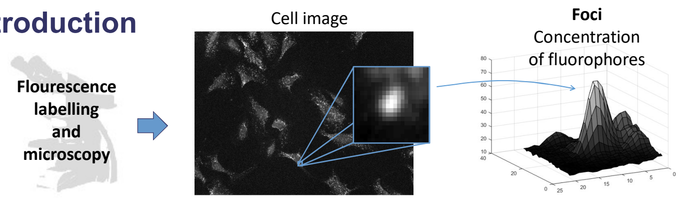
Foci Detection using Deep Learning

Julie Liv Cetti Hansen, MSc. Student
DTU Compute, Technical University of Denmark, 2017
Supervisors: Søren Blaaberg, Cecilia Klyver, Nicki Skafte Detlefsen, Rasmus Reinhold Paulsen

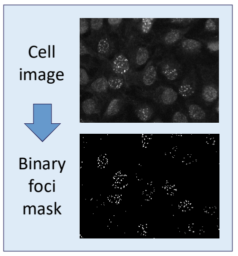
Introduction



Foci appear as bright spots inside cells. Analysis of foci can provide information about cellular mechanisms and pathways, fx DNA damage, DNA repair, the impact of a drug.

Foci detection

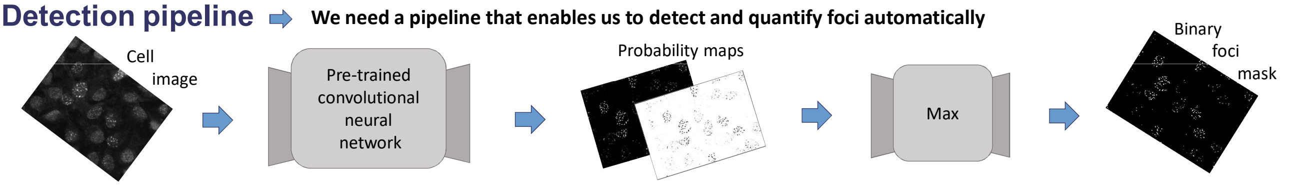
- Manual annotation ➡ cumbersome and time consuming.
- Manual foci detection is affected by human inconsistencies [1] ➡ different biological interpretations.
- There exists a desire for a fully automated and consistent foci detector.



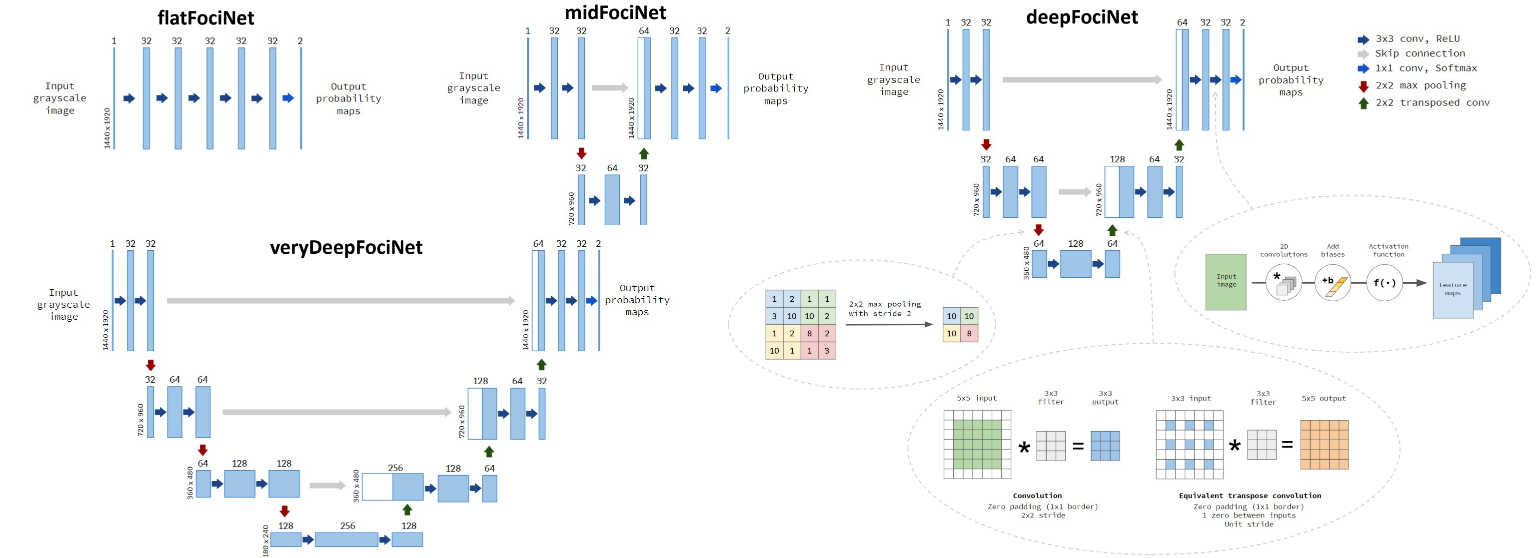
Problem formulation

Investigate the application of CNNs for the task of foci detection.

Detection pipeline ➡ We need a pipeline that enables us to detect and quantify foci automatically



Convolutional neural networks for segmentation (inspired by U-net [2])



Data

Images acquired on Xcyto®10

194 images converted to grayscale images of size 1920×1440

Training set 105 images

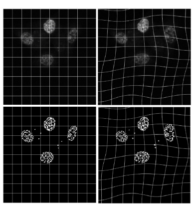
Validation set 41 images

Test set 48 images

Data augmentation

Random elastic deformatins
(and other methods...)

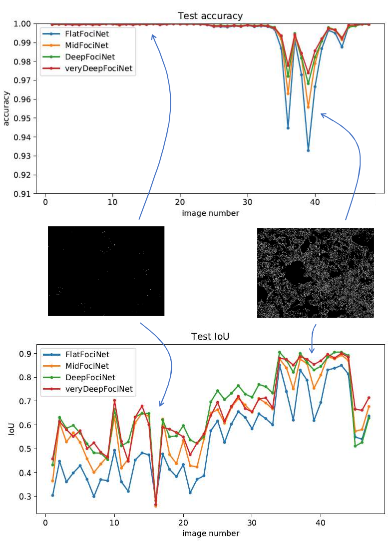
➡ Realistic deformations of cells



Augmented training set: 945 images

Results

We need multiple performance measures
(even more than the ones shown on this poster)



	Accuracy	IoU
flatFociNet	0.9930 ± 0.0014	0.5167 ± 0.0188
midFociNet	0.9953 ± 0.0001	0.5484 ± 0.0523
deepFociNet	**0.9961 ± 0.0001**	**0.6651 ± 0.0127**
veryDeepFociNet	**0.9961 ± 0.0001**	0.6440 ± 0.0070

ANOVA and Tuckey's tests showed no statistical significant difference between the performance of deepFociNet and veryDeepFociNet.

➡ We reach a **limit** for which increasing the **depth** and **complexity** does not further increase the performance.

Validation by experts

	Equal performance (%)	Prediction best (%)	Ground thruth best (%)
How well foci labels cover foci pixels	35.42 ± 23.48	29.86 ± 8.42	34.72 ± 23
How well adjacent foci labels are separated	52.08 ± 9.55	22.92 ± 2.08	25.00 ± 20.42

T-tests showed no statistical significant difference in performance between predictions and ground truth. Additionally, the large variances confirm variations in human foci assignment.

➡ Overall, this study demonstrated **proof of concept** of the application of CNNs for the task of foci detection.

[1] Herbert, A. D., Carr, A. M., & Hoffmann, E. (2014). FindFoci : A Focus Detection Algorithm with Automated Parameter Training That Closely Matches Human Assignments , Reduces Human Inconsistencies and Increases Speed of Analysis, 1–33.
[2] Ronneberger, O., Fischer, P., & Brox, T. (2015). U-Net: Convolutional Networks for Biomedical Image Segmentation, 1–8. https://doi.org/10.1007/978-3-319-24574-4_28