nucleAlzer: nucleus segmentation with DL & image style transfer

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CytoData 2020
Introduction

• Task
  • Detect nuclei
  • Segment nuclei

• Issues

• Goal

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• Task
• Issues
  • Experimental conditions change
  • Big data
  • Cancer cells
  • Expert knowledge needed
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Introduction

• Task
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• Goal
  • a robust, reliable, accurate method
Our idea
Motivation

original

Hollandi et al. 2020 Cell Syst
Motivation

Hollandi et al. 2020 Cell Syst
Motivation

Hollandi et al. 2020 Cell Syst
Motivation

Hollandi et al. 2020 Cell Syst
Motivation

Hollandi et al. 2020 Cell Syst
Our idea

• Image style transfer
• Large training set needed
• New conditions
nucleAlzer in brief

Cell Systems

nucleAlzer: A Parameter-free Deep Learning Framework for Nucleus Segmentation Using Image Style Transfer

Authors
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In Brief
Microscopy image analysis of single cells can be challenging but also eased and improved. We developed a deep learning method to segment cell nuclei. Our strategy is adapting to unexpected circumstances automatically by synthesizing artificial microscopy images in such a domain as training samples.

Highlights
- Robust method automatically adapting to various unseen experimental scenarios
- Deep learning solution for accurate nucleus segmentation without user interaction
- Accelerates, improves quality, and reduces complexity of bioimage analysis tasks

• Instance segmentation DL pipeline
• Image style transfer
• Online tool
http://www.nucleaizer.org/

Hollandi et al. 2020 Cell Syst
Proposed solution

a) Pipeline. b) Augmentation with image style transfer
Proposed solution
Proposed solution

- **Pre-segmentation**: Size estimation using Mask-RCNN
- **Size normalization**: Tensor resize
- **Fine segmentation**: Mask-RCNN
- **Post-processing**: UNet morphology operations

Augmentation:
- Data clustering
- pix2pix style transfer

Training:
- Fine tuning
- Mask-RCNN
Proposed solution

Hollandi et al. 2020 Cell Syst
Proposed solution
Proposed solution

Fig. 4: a) Pipeline. b) Augmentation with image style transfer

Original images → Clustering → Building style models → Applying style models

- Style model for style no. 2
  - original images
  - original masks

Synthetic mask generation
- nuclei mask database
- synthetic masks

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Proposed solution

Fig. 4: a) Pipeline. b) Augmentation with image style transfer

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Proposed solution

Fig. 4: a) Pipeline. b) Augmentation with image style transfer

Hollandi et al. 2020 Cell Syst
Proposed solution

**Fig. 4:** a) Pipeline. b) Augmentation with image style transfer

Hollandi et al. 2020 Cell Syst
Proposed solution

Fig. 4: a) Pipeline. b) Augmentation with image style transfer

Hollandi et al. 2020 Cell Syst
Spot the fakes!
Spot the fakes!
Proposed solution

Hollandi et al. 2020 Cell Syst
Proposed solution

- **Pre-segmentation**: size estimation using Mask-RCNN
- **Size normalization**: tensor resize
- **Fine segmentation**: Mask-RCNN
- **Post-processing**: UNet morphology operations

**Augmentation**
- data clustering
- pix2pix style transfer

**Training**
- fine tuning
- Mask-RCNN

*Hollandi et al. 2020 Cell Syst*
Post-processing

A) scheme, B) real example, C) input & output

Hollandi et al. 2020 Cell Syst
Results

- DSB 2018
- BIOMAG lab
Results

• DSB 2018
• Challenging images
Results

• DSB 2018
  • Challenging images

Example test images from DSB 2018
Results

Example test images with our solution outlined
Results

• DSB 2018

Complicated scenarios
Results

• DSB 2018
• BIOMAG lab
  • High-throughput pathological experiments
Results

Mouse kidney IHC
Results

Mouse kidney IHC
Results

Kidney cancer H&E
Results

Kidney cancer H&E
Results

U2OS Actin & Tubulin fluorescent, cytoplasm
Results

U2OS Actin & Tubulin fluorescent, cytoplasm
Results

Ovarian cancer, fluorescent, membrane
Results

Ovarian cancer, fluorescent, membrane

(DK) UCPH Mann group
Results

Insect cells fluorescent + brightfield, cytoplasm

(H) BRC Viktor Honti
Results

Insect cells fluorescent + brightfield, cytoplasm

(H) BRC Viktor Honti
Results

Leukemia + bone marrow co-culture, fluorescent

(CH) Leukemia group
Results

GW screen nuclei + nucleoli

(CH) ETHZ Kutay group
Results

GW screen nuclei + nucleoli

(CH) ETHZ Kutay group
Results

HeLa cells, fluorescent, nuclei in syncytium
Results

HeLa cells, fluorescent, nuclei in syncytium

(Univ. Bristol, Yohei Yamauchi)
Proof of concept results

Hollandi et al. 2020 Cell Syst
Proof of concept results

Colour-coded examples

original

NOstyle

style

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Proof of concept results

original

NOstyle

style

Hollandi et al. 2020 Cell Syst
Proof of concept results

original

NOstyle

style

+ explanation

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Proof of concept results

Hollandi et al. 2020 Cell Syst
Proof of concept results

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Proof of concept results

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Hollandi et al. 2020 Cell Syst
Proof of concept results

Hollandi et al. 2020 Cell Syst
Proof of concept results

Colour-coded examples

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But why this method?
Issues

• Expert knowledge needed
Issues

• Experimental conditions change

Image analysis software

Proposed method

- As a black box

Our method as a black box
Proposed method

• Open it

"the" method

Exploring our method
Proposed method

- Open it
- Modify
- Tune

"the" method

Exploring our method
Proposed method

- Open it
- Modify
- Tune
- Explore the technology

“the” method

https://github.com/spreka/biomagdsb

Exploring our method
Proposed method

• Open it
• Modify
• Tune
• Explore the technology
• Issues & ideas

https://github.com/spreka/biomagdsb
But how?
Play around with it

Play around with it

• Upload images & select a model
Alternatively...
Annotation project

Hollandi et al. 2020 MolBiolCell

https://github.com/spreka/annotatorj
Acknowledgements

Péter Horváth
• Ábel Szkalisity
• Ervin Tasnádi
• Csaba Molnár
• Tivadar Danka
• András Kriston
• Tímea Tóth
• Mária Kovács
• Krisztián Koós

• Ferenc Kovács
• Norbert Bara
• István Grexa
• Tamás Balassa
• Máté Görbe
• Árpád Bálint
• József Molnár
• Ede Migh

• Lassi Paavolainen
• Kevin Smith

• Anne E. Carpenter
• Allen Goodman
Thank you for your attention