

Computer vision tasks and their applications in medicine and life sciences

Sonja Aits

“AI for Medicine and Life Science – AI for image and video data”

Lund University

20211018

Examples of computer
vision?

Computer Vision

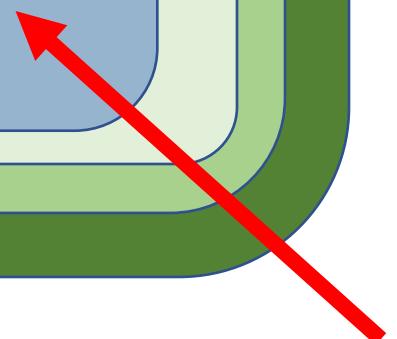
= AI for processing, analysis or generation of images or videos

Artificial intelligence

Machine learning

Deep learning

**Computer
vision**



Computer vision is challenging

- Variable viewpoints
- Variable scale
- Deformable and/or moving objects
- Occlusion
- Variable illumination
- Intra-class variation
- Variable background
- Noise

How do computers perceive images and videos?



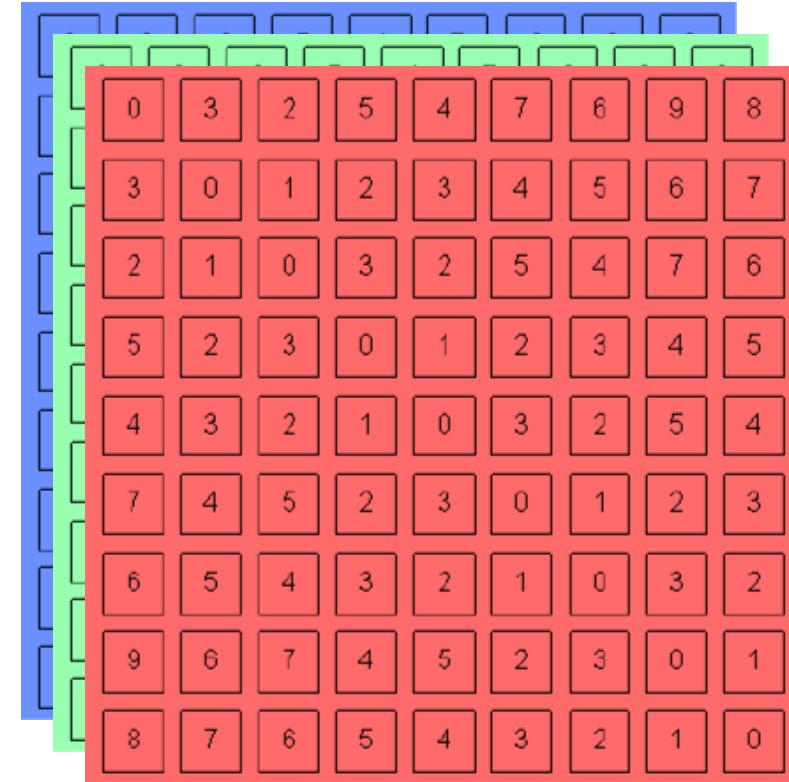
0	3	2	5	4	7	6	9	8
3	0	1	2	3	4	5	6	7
2	1	0	3	2	5	4	7	6
5	2	3	0	1	2	3	4	5
4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

Pixel intensities:

8-bit greyscale: 0 – 255 (2^8)

16-bit greyscale: 0 - 65 535 (2^{16})

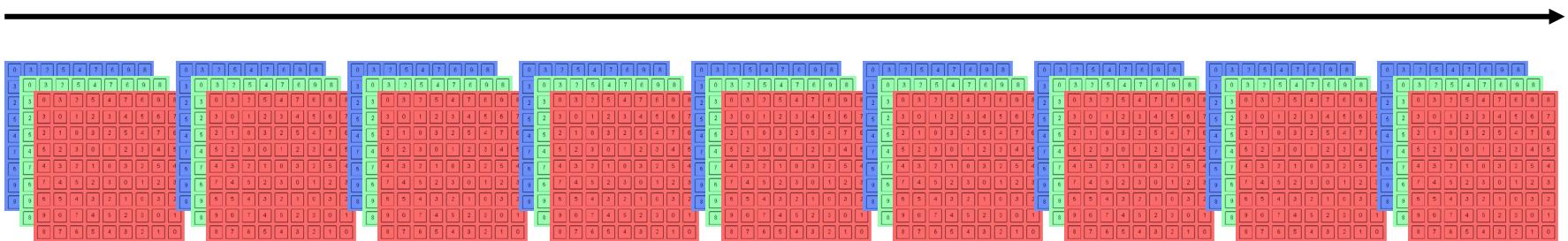
How do computers perceive images and videos?



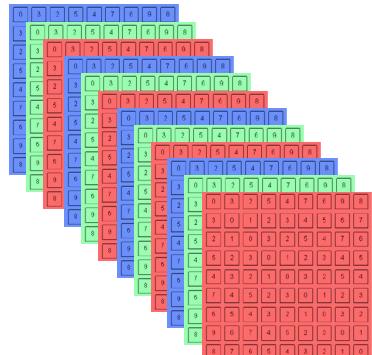
RGB

How do computers perceive images and videos?

Video

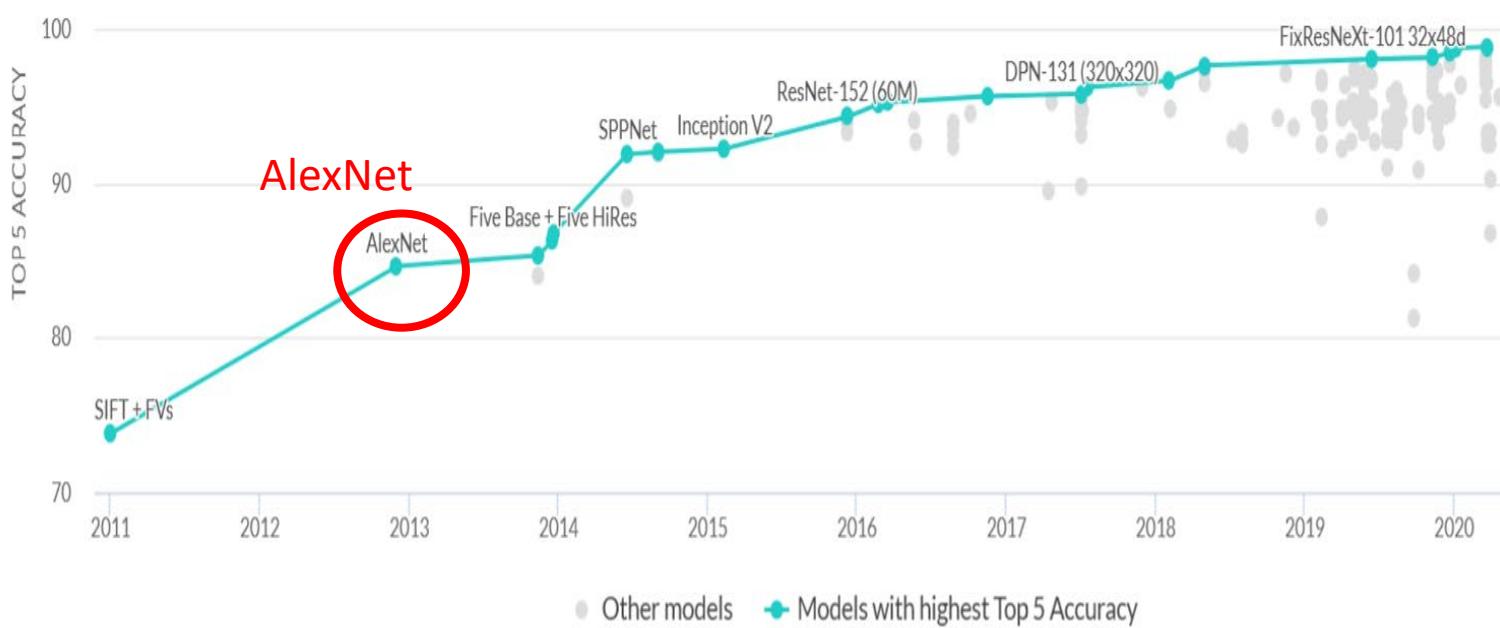


3D



AlexNet: the breakthrough of GPU-driven Deep Learning

ImageNet Large Scale Visual Recognition Challenge (ILSVRC)

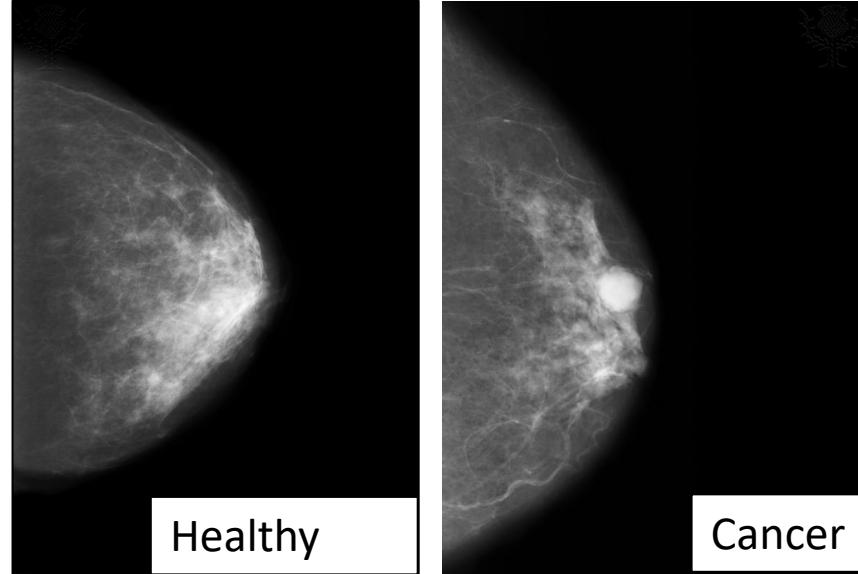


<https://paperswithcode.com/sota/image-classification-on-imagenet?metric=Top%205%20Accuracy>

<https://cs.stanford.edu/people/karpathy/cnnembed/>

Image classification

Binary



Output:
Image class

Multi-class

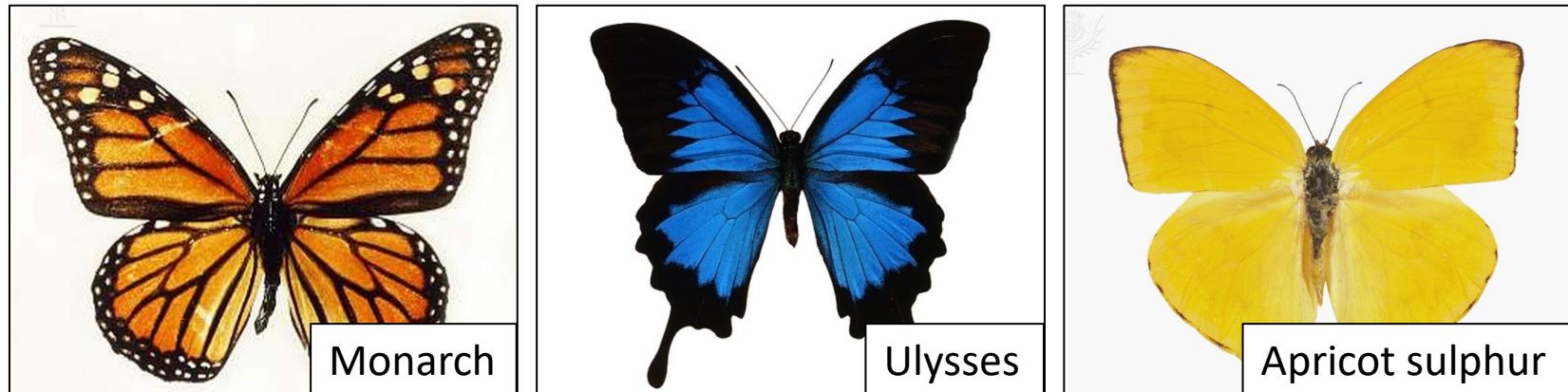
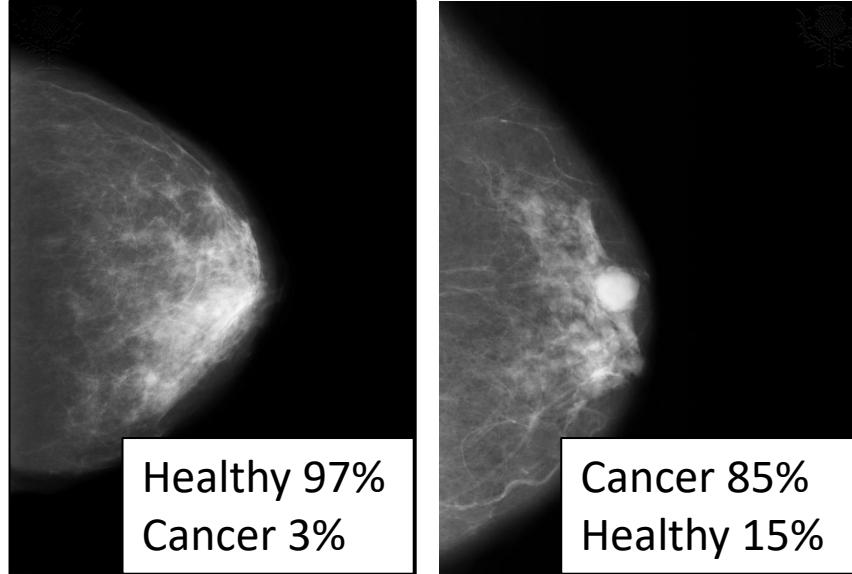


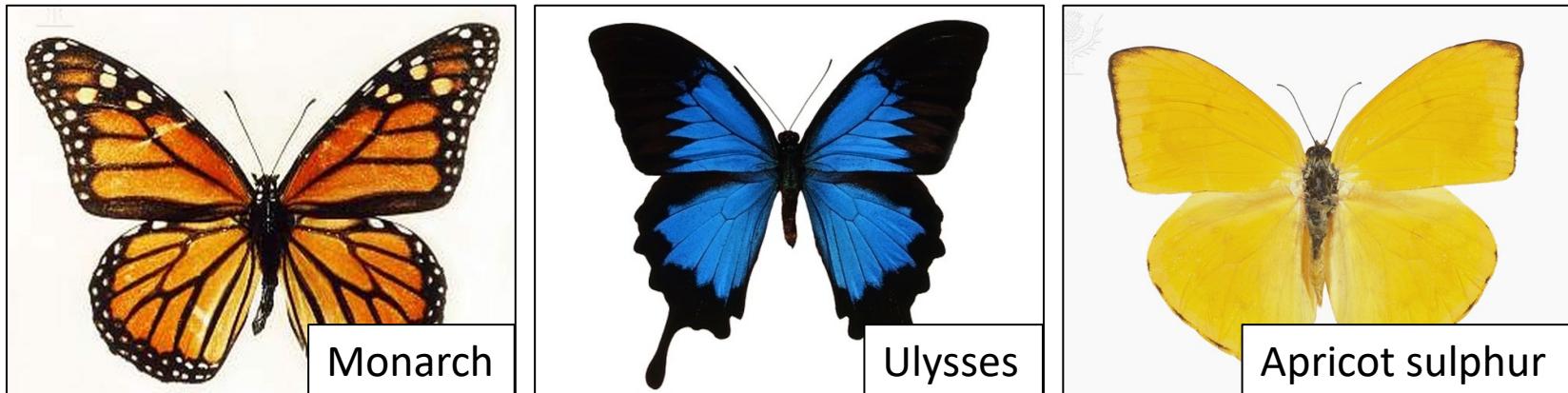
Image classification

Binary

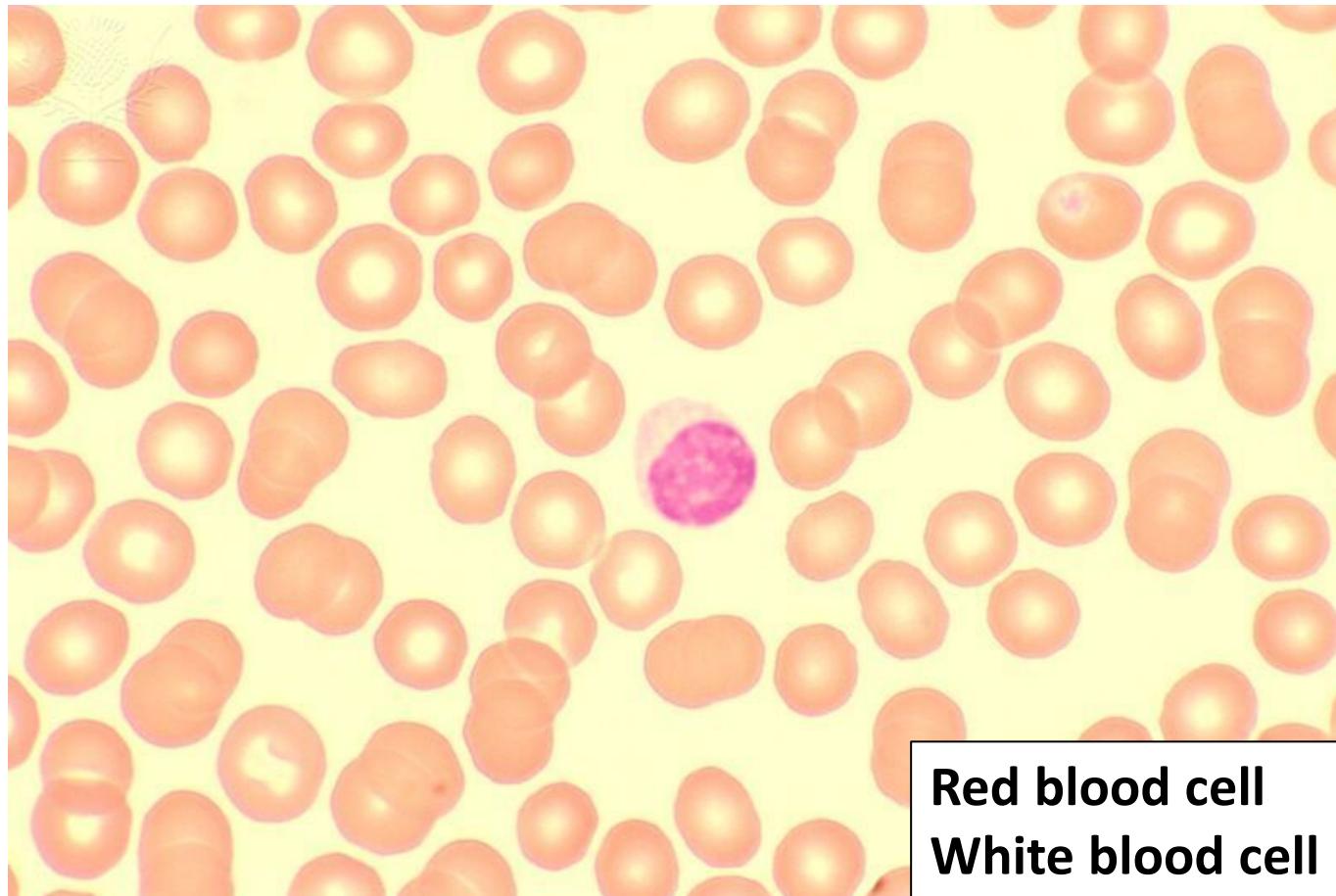


Output:
Image class

Multi-class



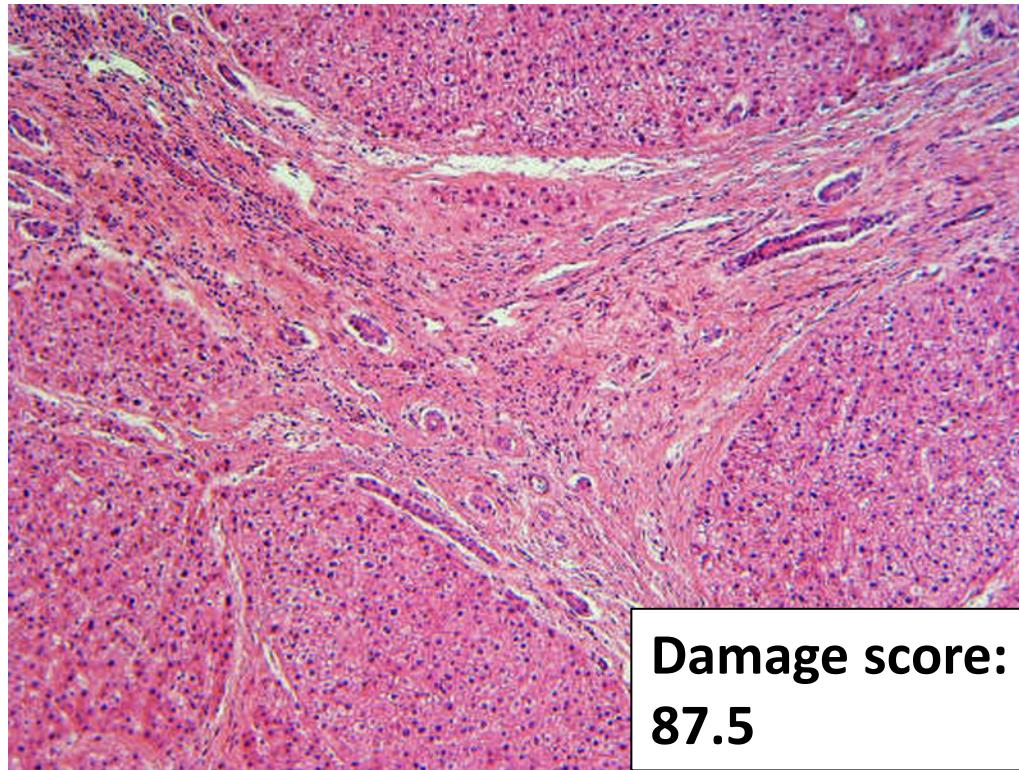
Multi-label image classification



**Red blood cell
White blood cell**

Output:
Multiple
image classes

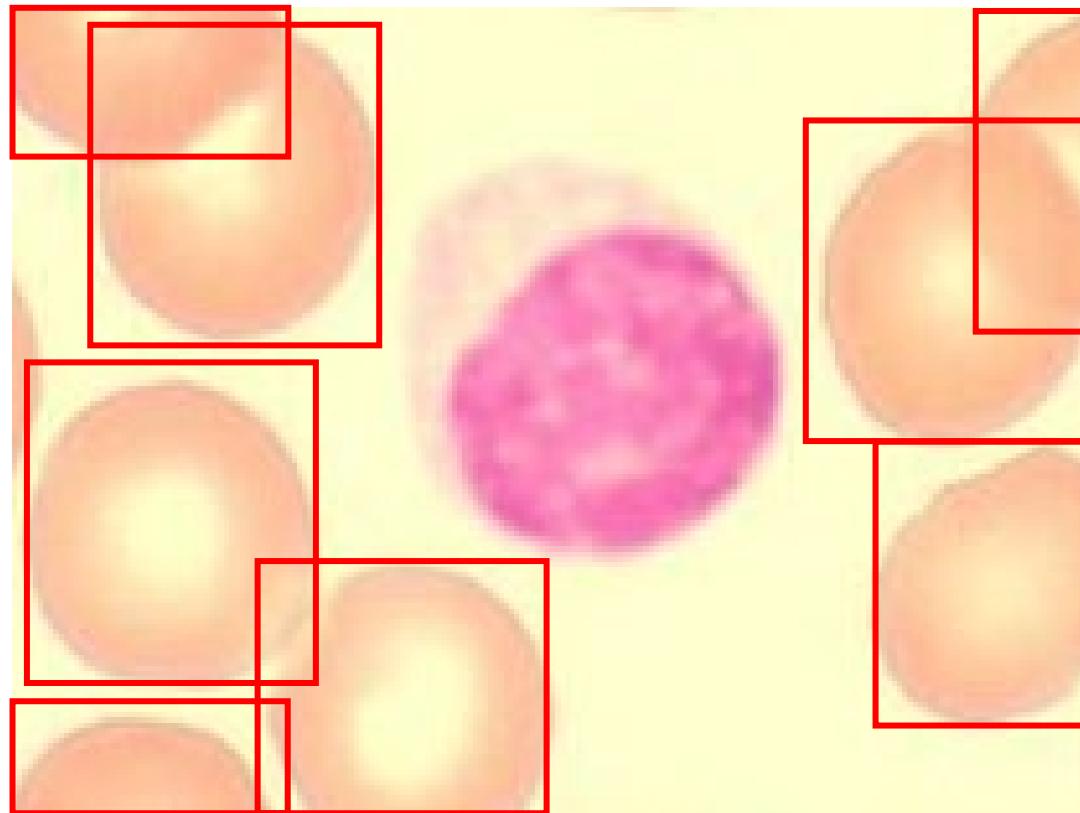
Image regression



Output:
Continuous value

Object detection

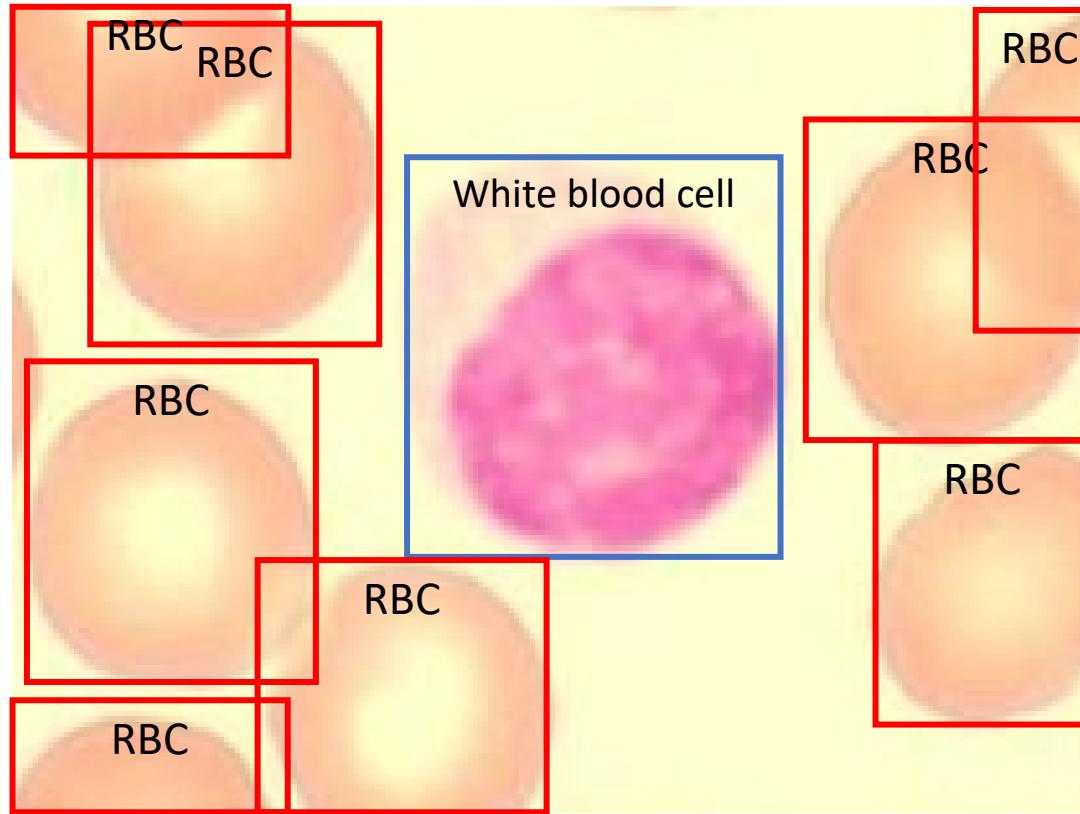
Single-class



Output:
Set of bounding boxes
(x , y , width, height)

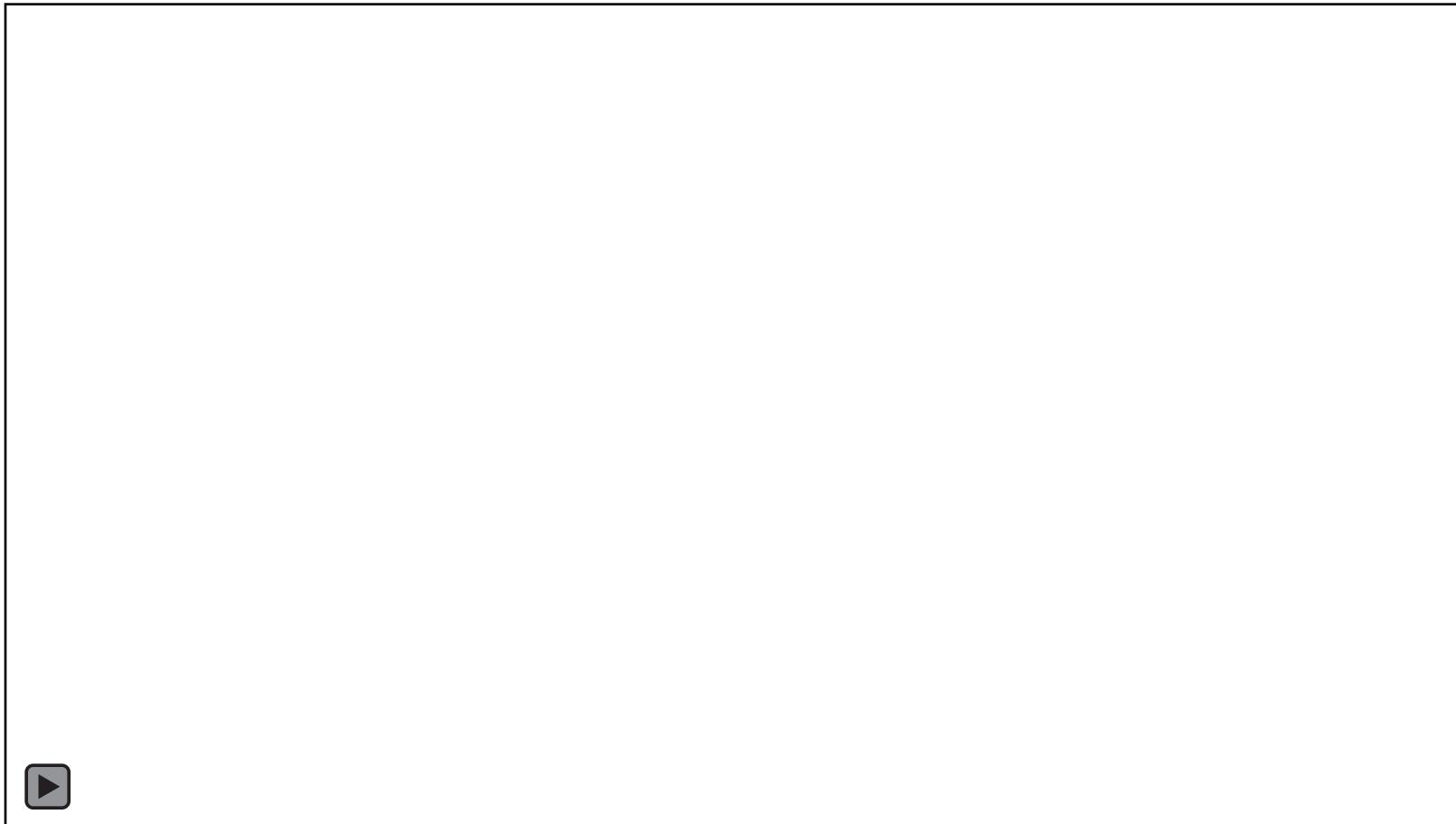
Object detection

Multi-class

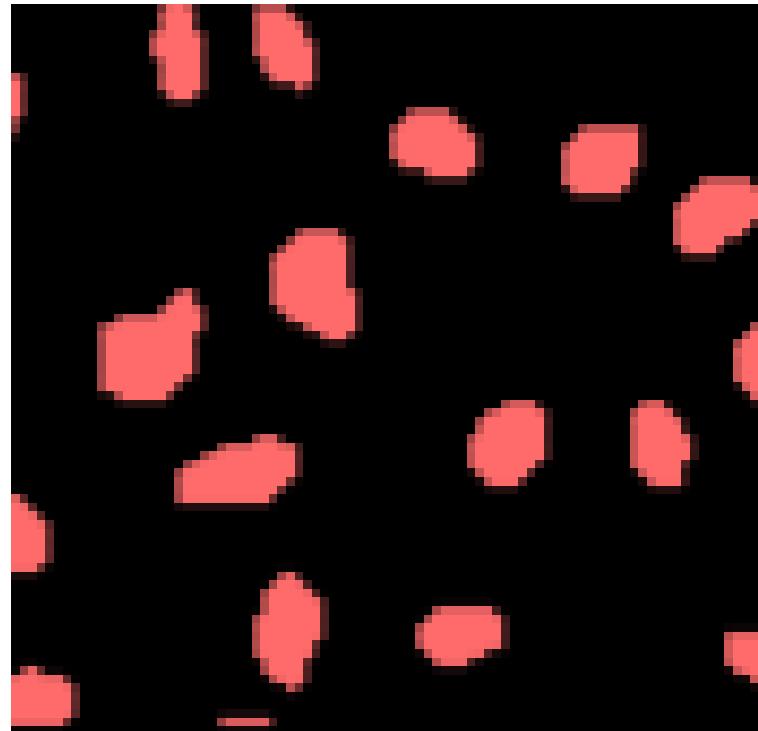
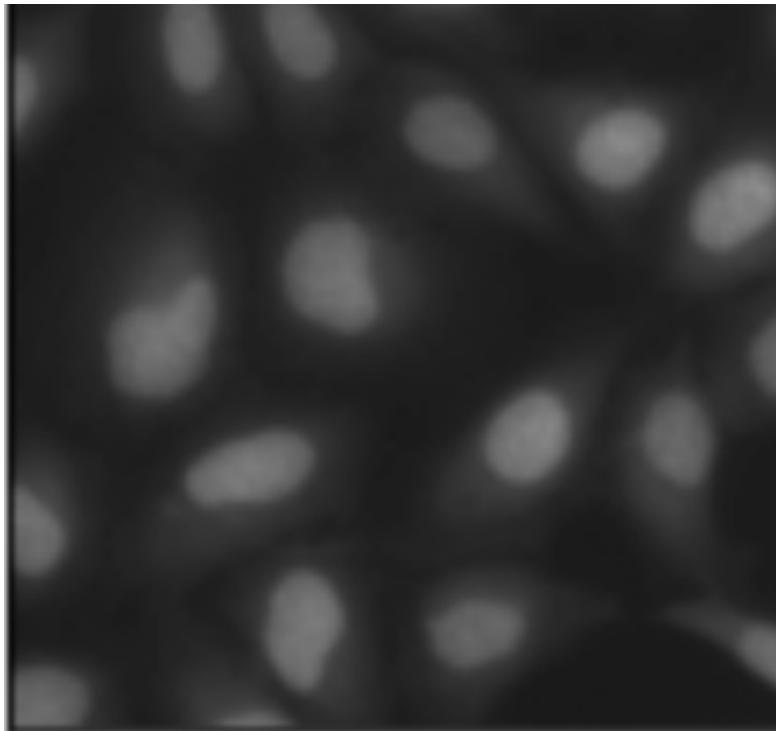


Output:
Set of bounding boxes
with object class

Object tracking



Semantic segmentation

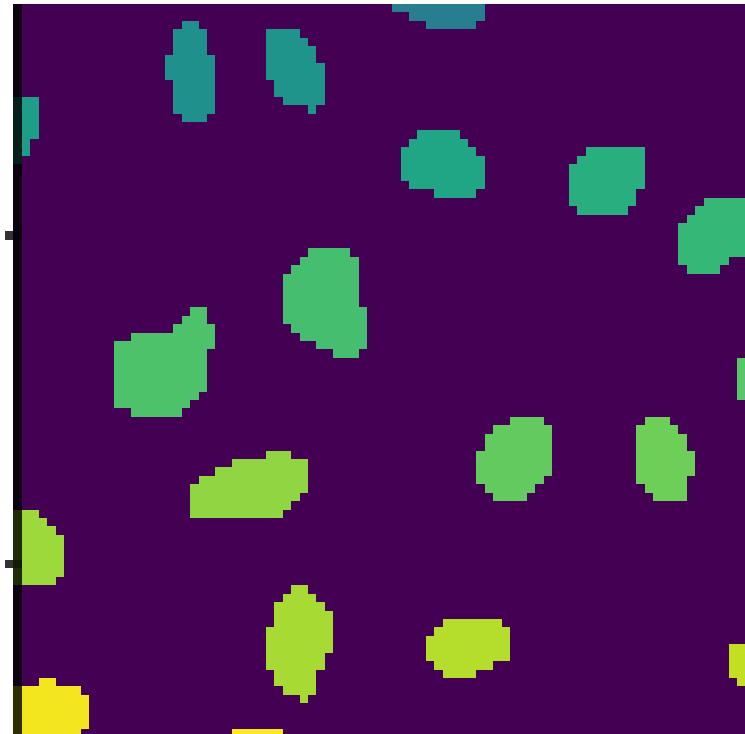
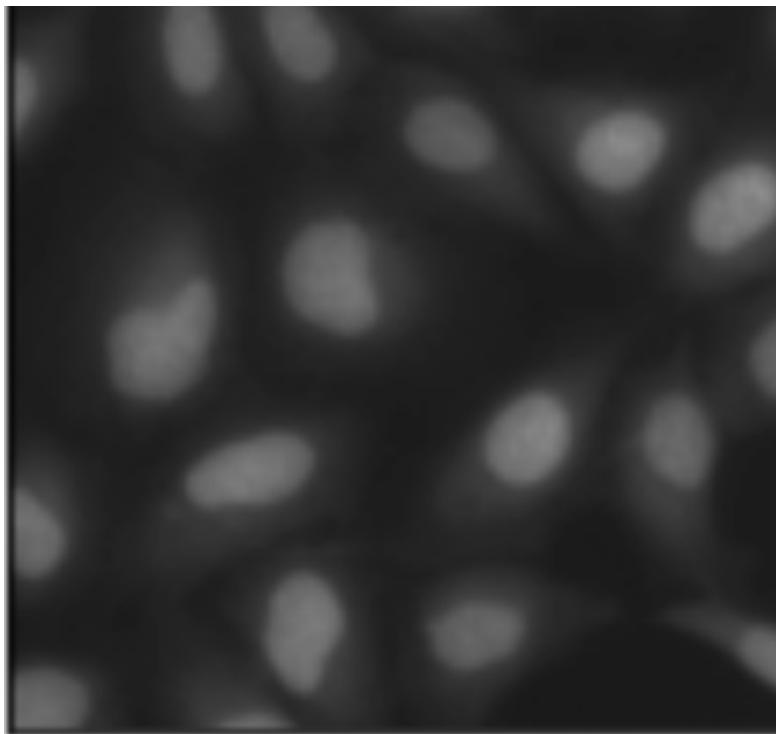


Background
Cells

Output:
Class of each pixel

No
information
on individual
objects!

Instance segmentation



Output:
Outlined objects

Pose estimation



Pose estimation: 3D

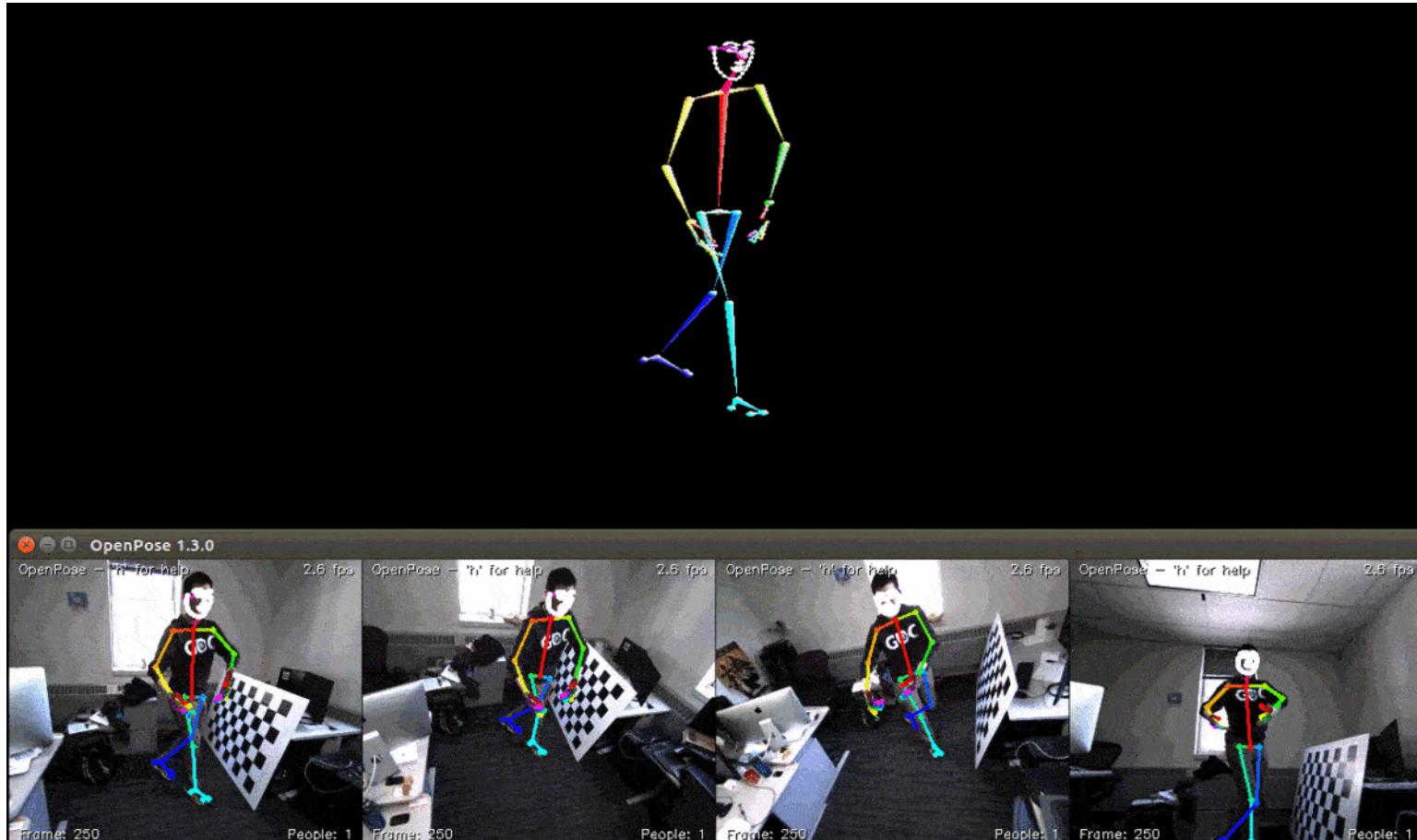


Image registration

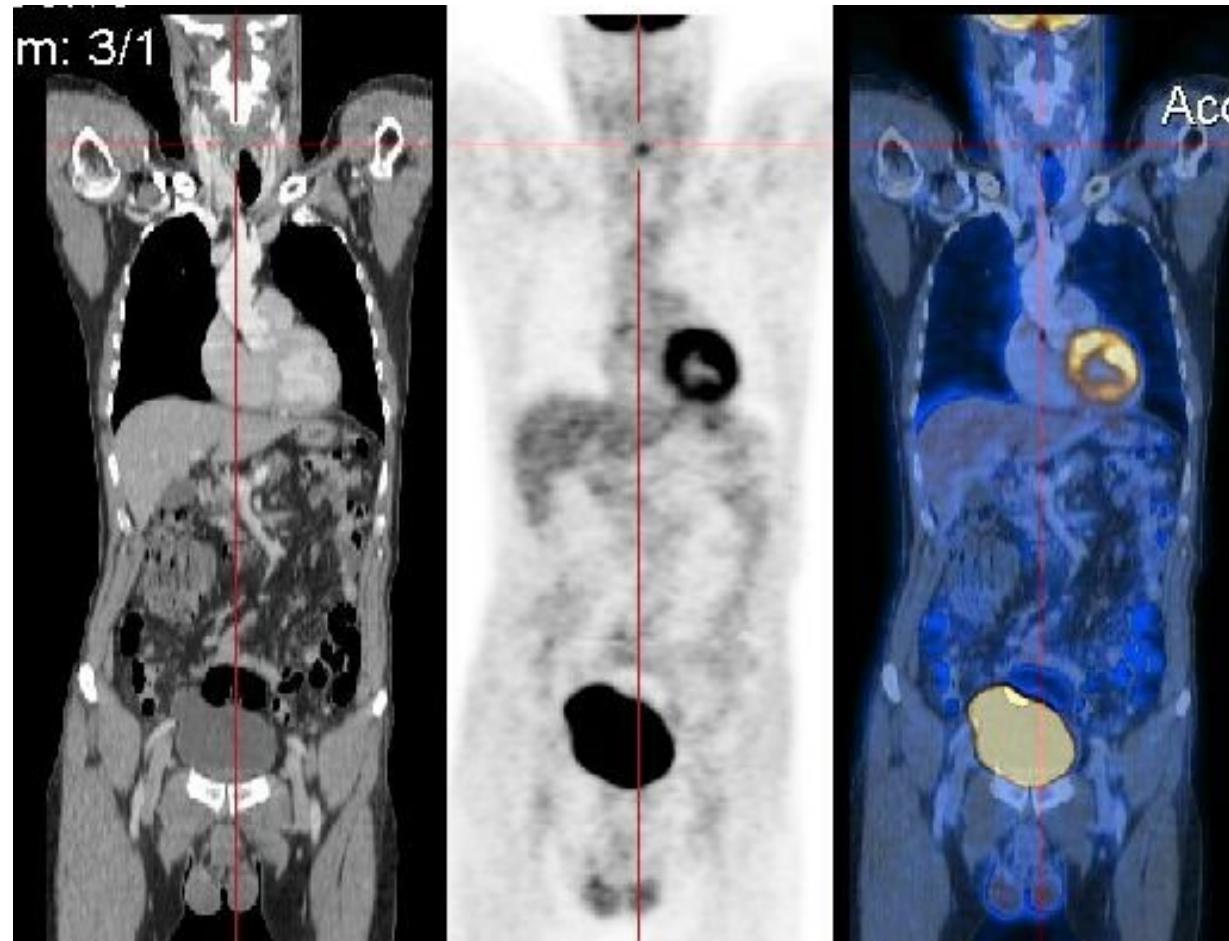
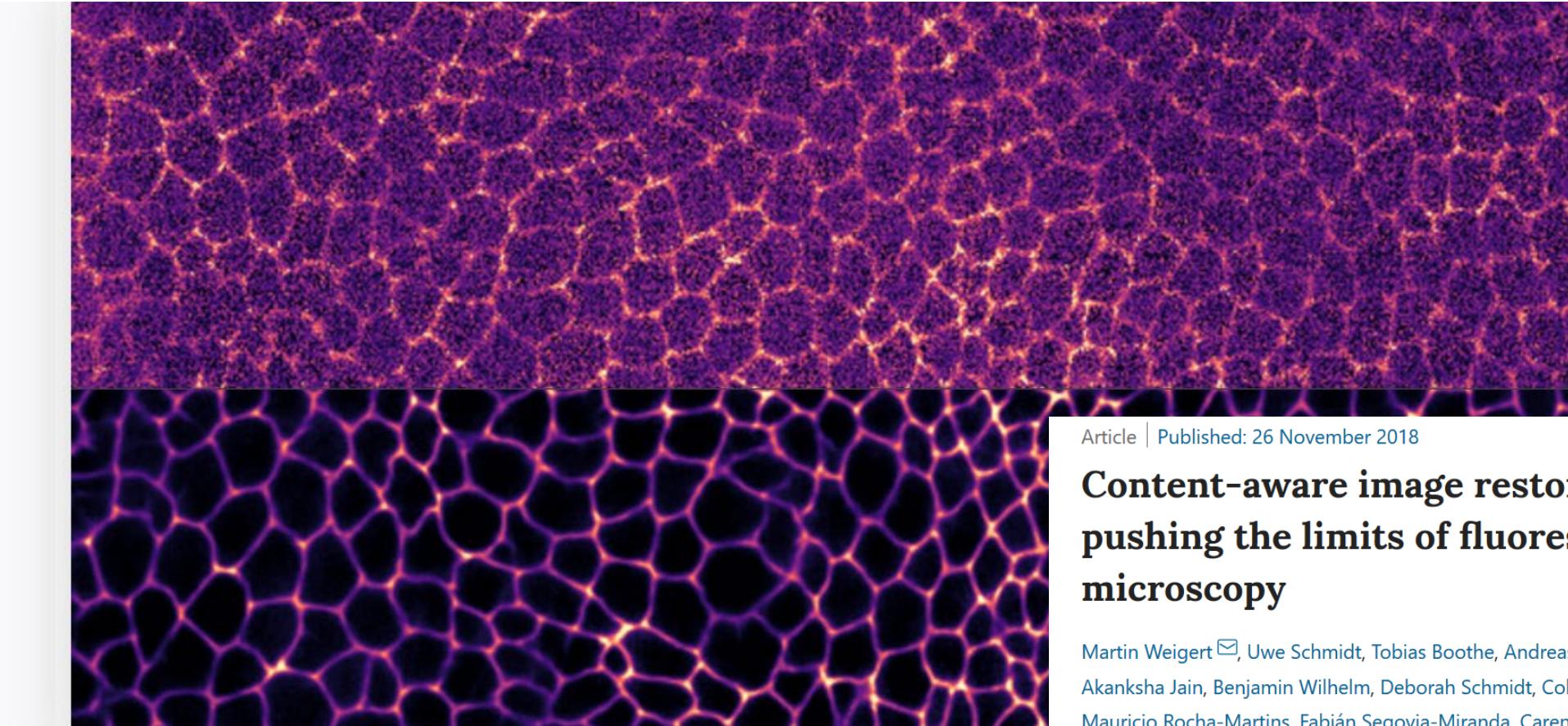


Image restoration



combined surface prediction + denoising

Article | Published: 26 November 2018

Content-aware image restoration: pushing the limits of fluorescence microscopy

Martin Weigert , Uwe Schmidt, Tobias Boothe, Andreas Müller, Alexandr Dibrov, Akanksha Jain, Benjamin Wilhelm, Deborah Schmidt, Coleman Broaddus, Siân Culley, Mauricio Rocha-Martins, Fabián Segovia-Miranda, Caren Norden, Ricardo Henriques, Marino Zerial, Michele Solimena, Jochen Rink, Pavel Tomancak, Loic Royer , Florian Jug  & Eugene W. Myers

Super-resolution

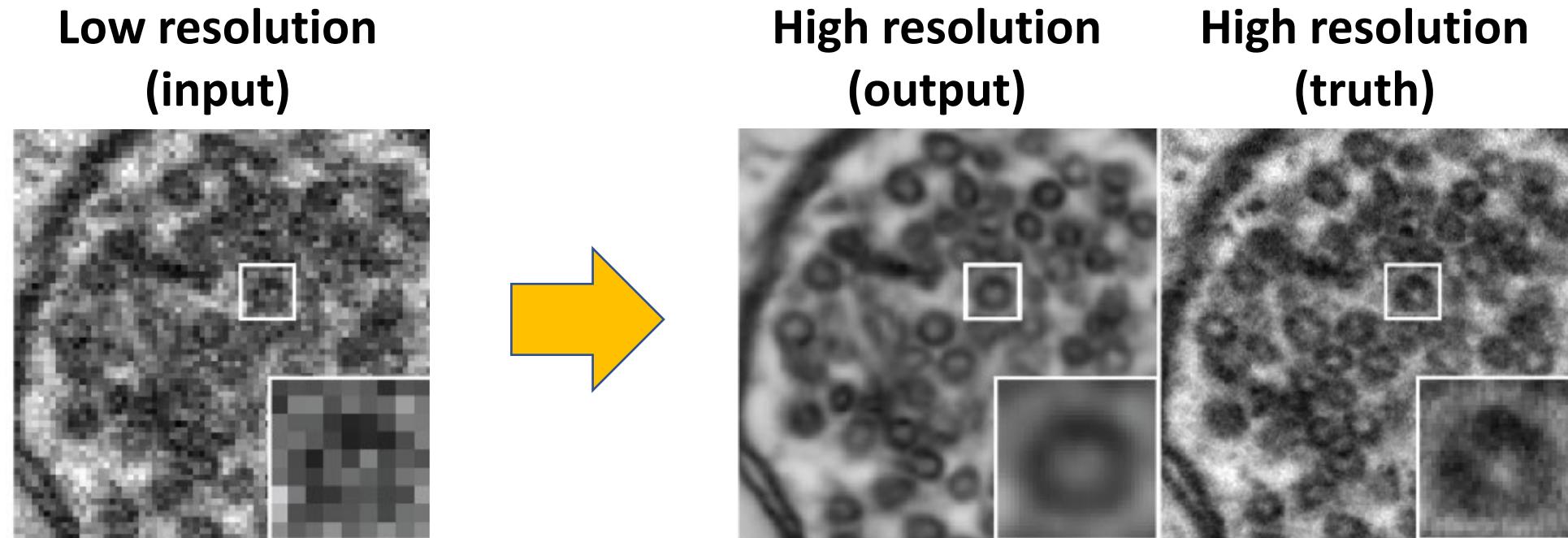
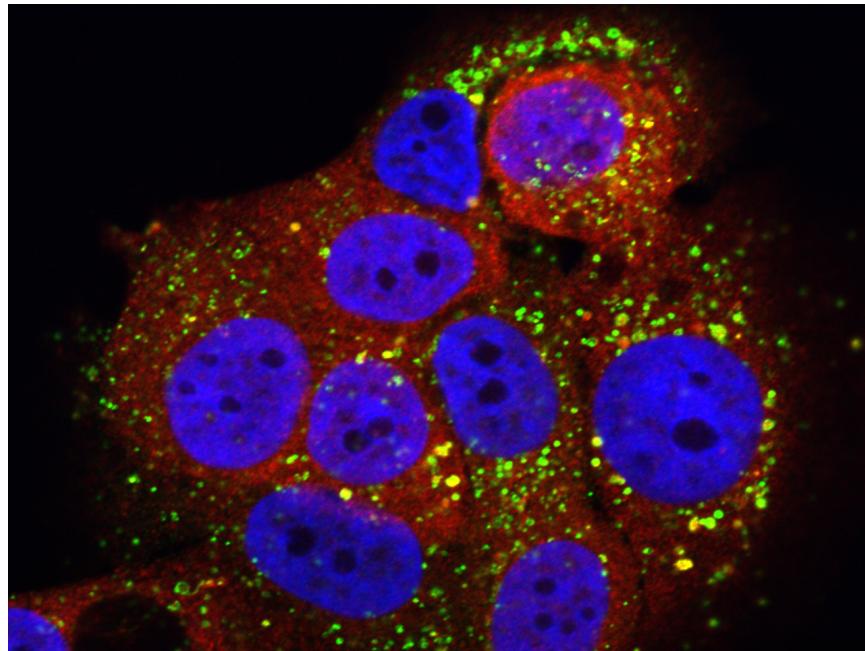


Image captioning

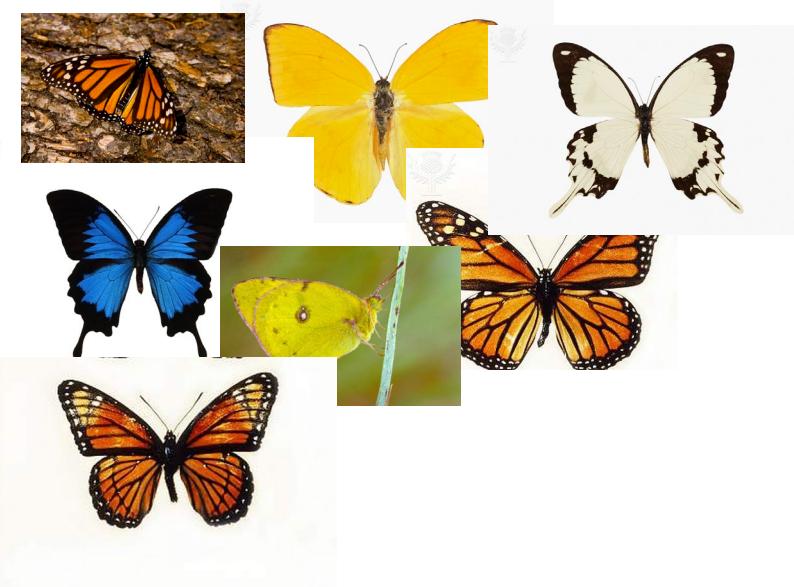


Output:
Descriptive word
sequence



“a fluorescence microscopy image showing a group of cells
with blue nuclei and bright green cytosolic spots”

Image clustering



Output:
Grouped data

Dimensionality reduction

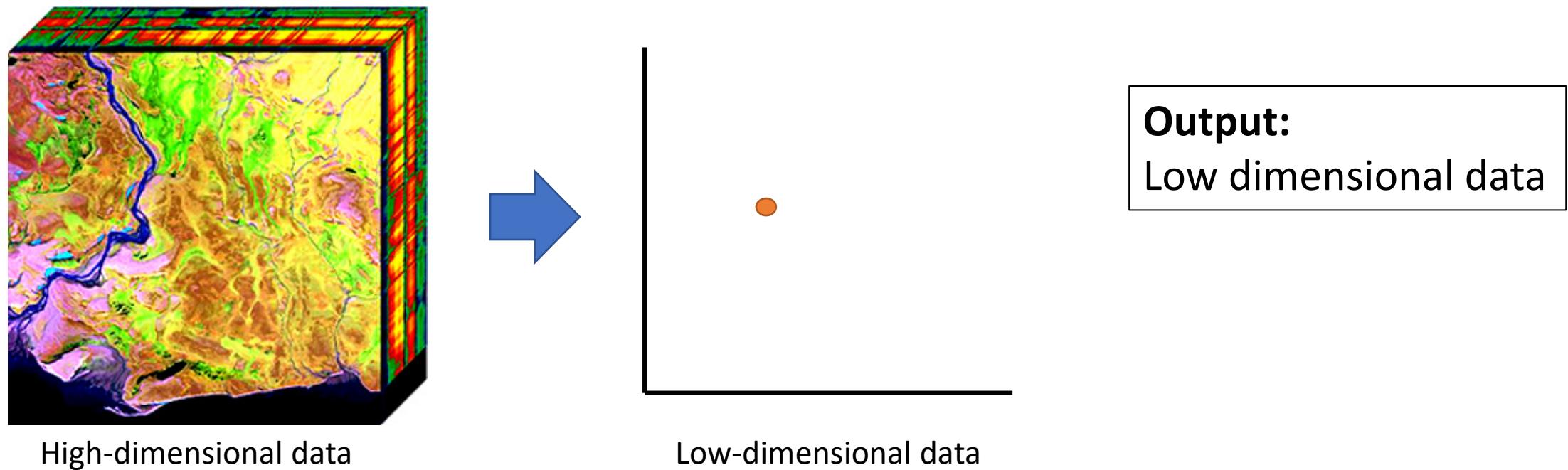
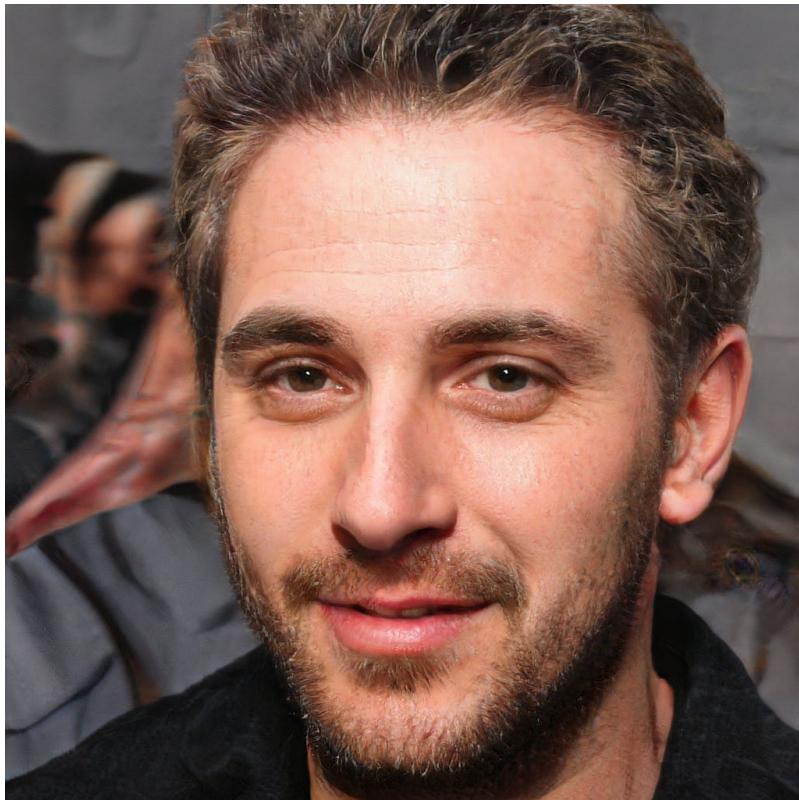


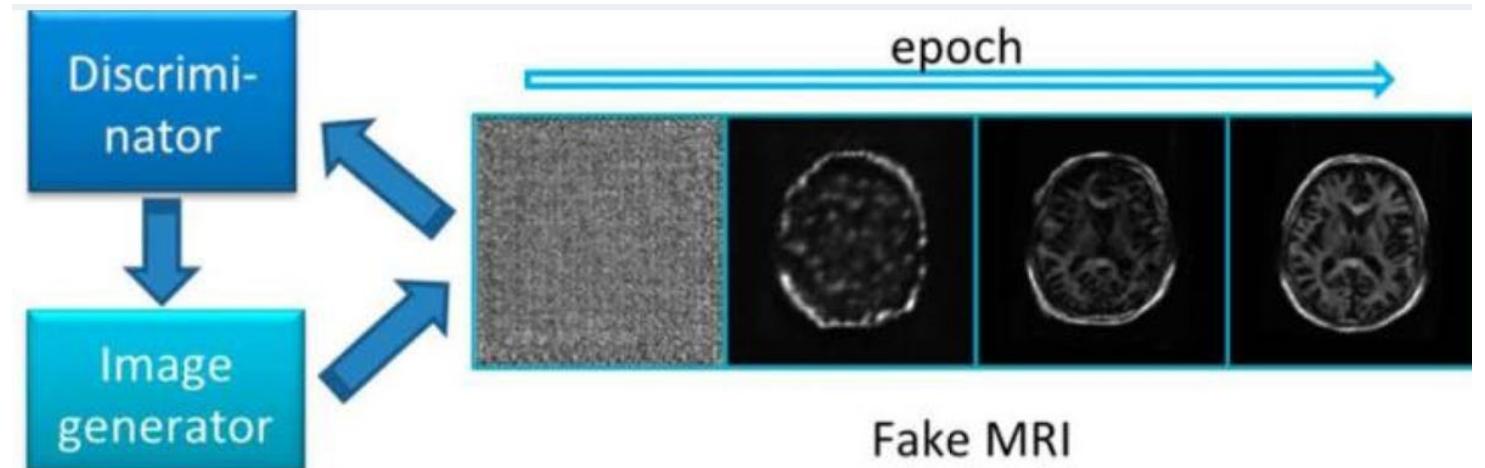
Image generation



[Tomography](#). 2018 Dec;4(4):159-163. doi: 10.18383/j.tom.2018.00042.

Generative Adversarial Networks for the Creation of Realistic Artificial Brain Magnetic Resonance Images.

Kazuhiro K¹, Werner RA^{2,3,4}, Toriumi F⁵, Javadi MS², Pomper MG^{2,6,7}, Solnes LB², Verde F⁷, Higuchi T^{1,3,4}, Rowe SP^{2,6,7}.



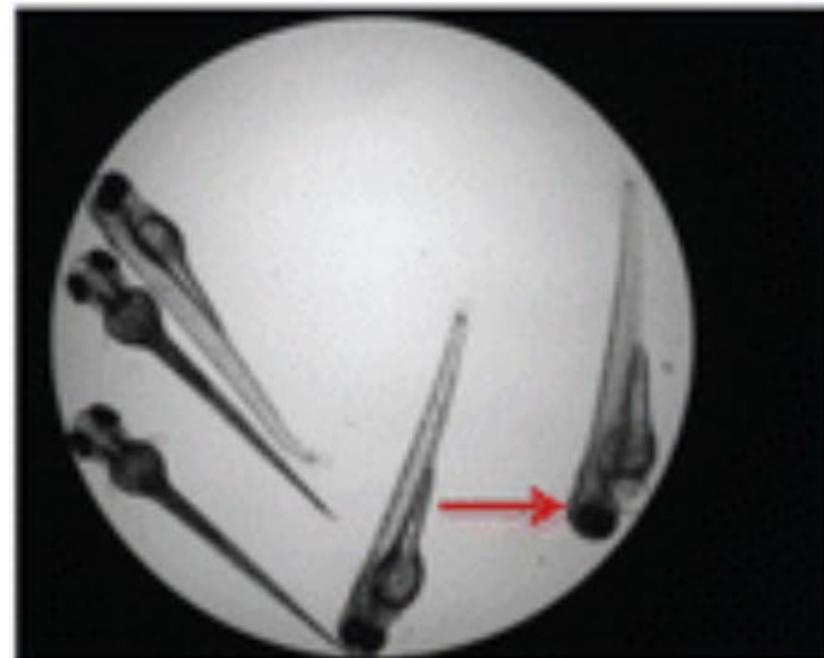
<https://thispersondoesnotexist.com/>

Neural networks “see” things humans cannot perceive...

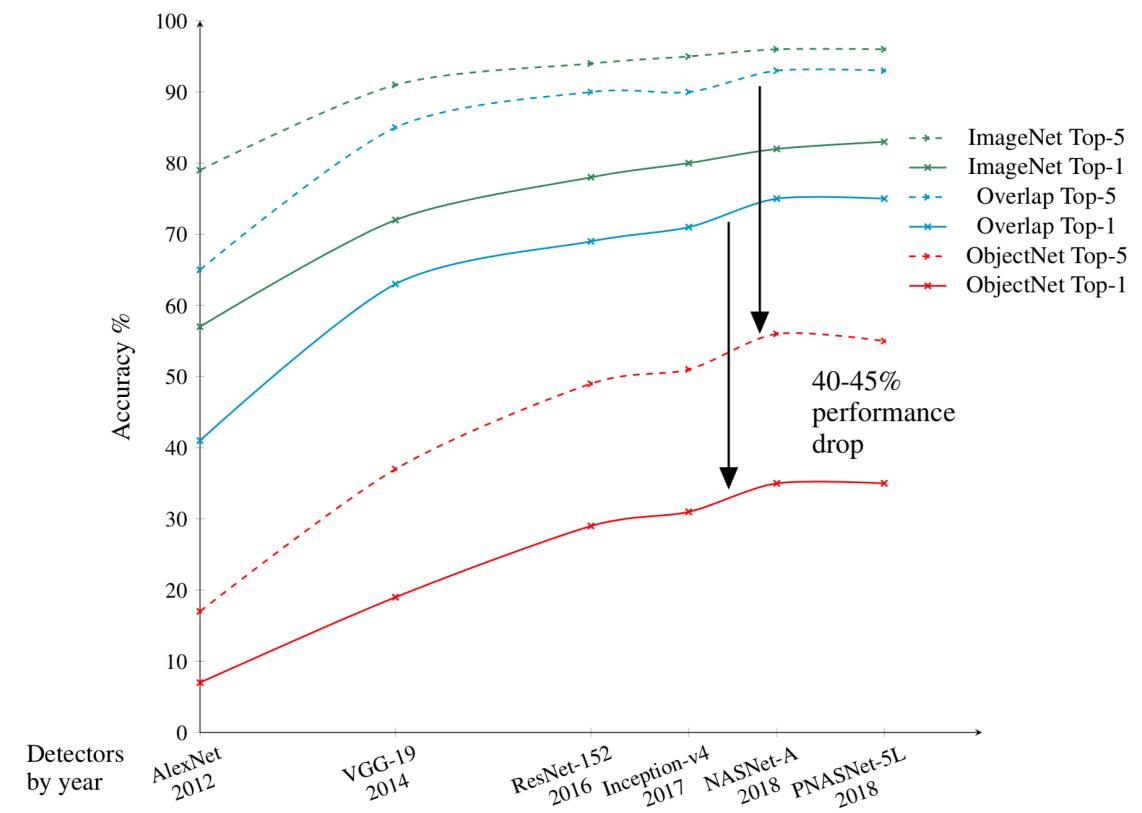
Unhealthy zebrafish



Healthy zebrafish



...but can struggle with problems that are easy for humans



...but can struggle with problems that are easy for humans



$$+ .007 \times$$



=



“panda”

57.7% confidence

noise

“gibbon”

99.3% confidence

Summary: common computer vision tasks

- Image classification
- Image regression
- Object detection
- Object tracking
- Semantic segmentation
- Instance segmentation
- Pose estimation
- Image registration
- Image restoration
- Super-resolution
- Image captioning
- Image clustering
- Dimensionality reduction
- Image generation

AI-based software for bioimage analysis

DeepImageJ: A user-friendly plugin to run deep learning models in ImageJ

 Estibaliz Gómez-de-Mariscal, Carlos García-López-de-Haro, Laurène Donati, Michael Unser,
 Arrate Muñoz-Barrutia, Daniel Sage

doi: <https://doi.org/10.1101/799270>



ilastik

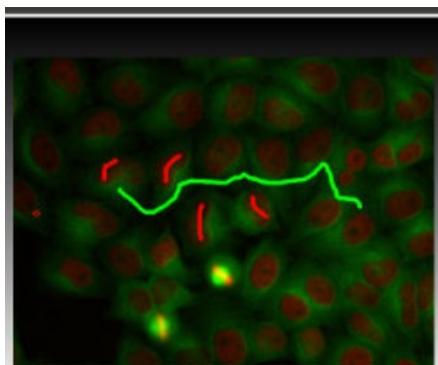
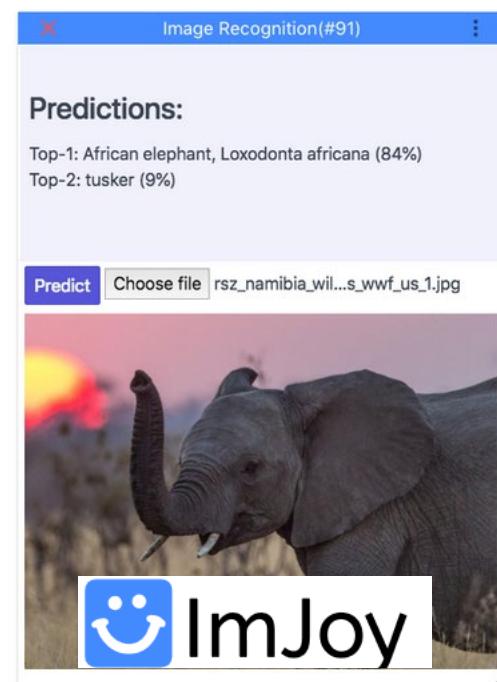


Image Recognition (#91)

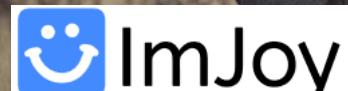
Predict Choose file rsz_namibia_wil...s_wwf_us_1.jpg

Predictions:

Top-1: African elephant, Loxodonta africana (84%)
Top-2: tusker (9%)



Commr



Commr

CellProfiler Analyst



Interactive data exploration, analysis, and classification of large biological image sets

