



Progress in Radiology 2018, June 14th 2018

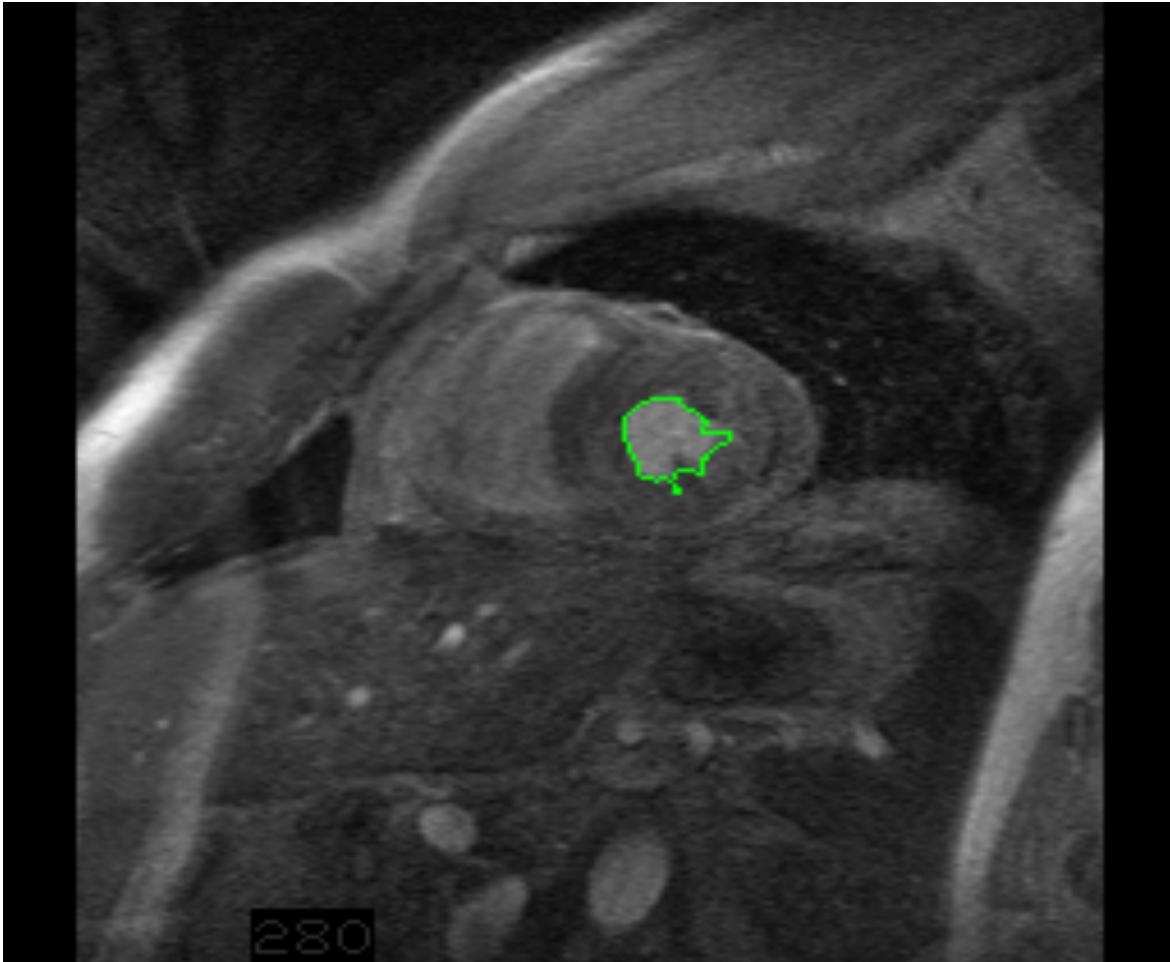
<https://www.uib.no/en/isrs2018>

Machine Learning for Precision Imaging

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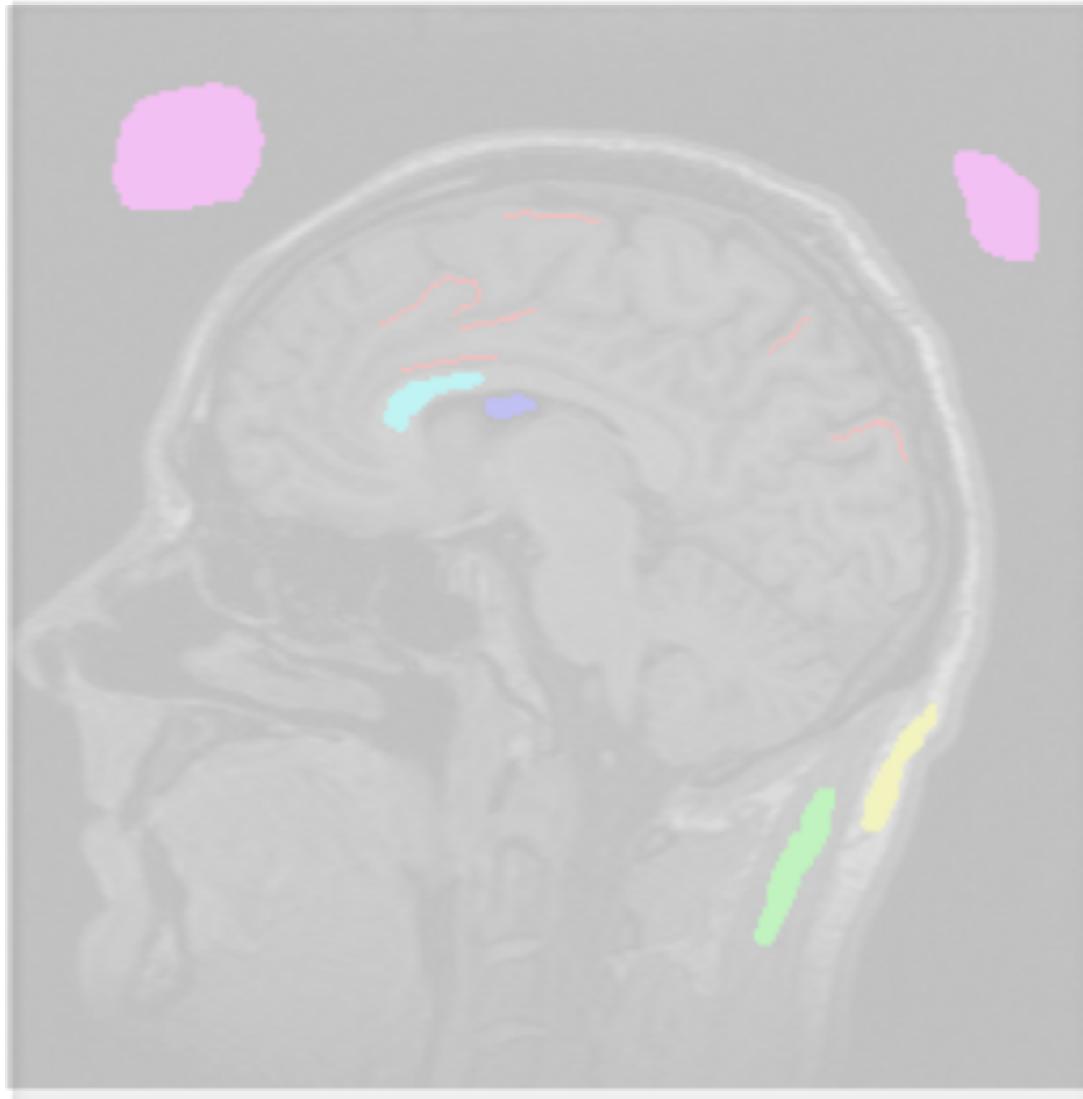
Computational imaging



Machine Learning

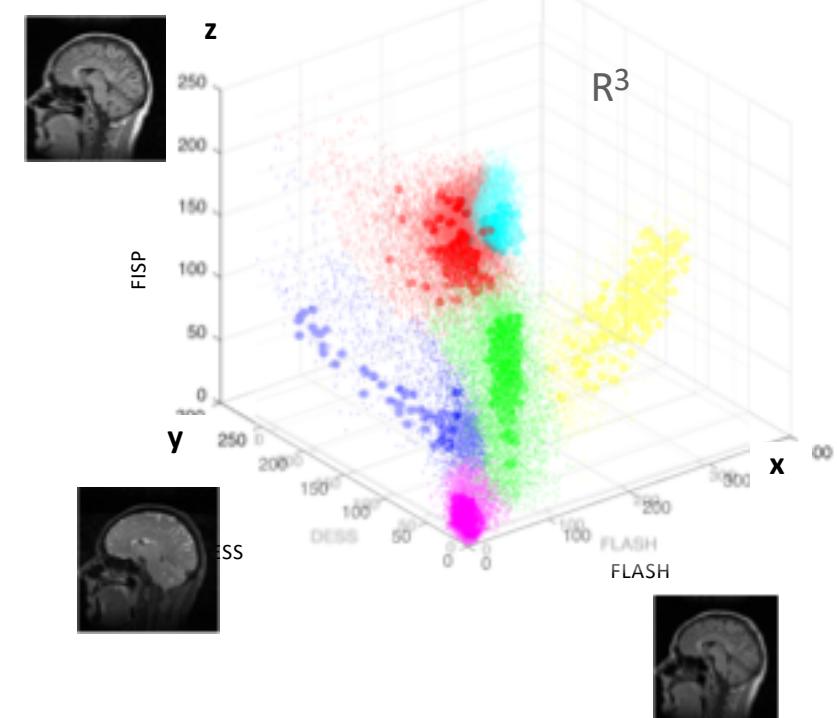
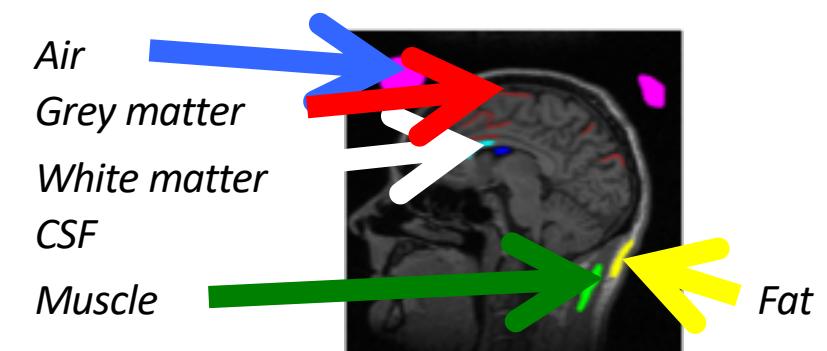
- A program or system that builds (trains) a **predictive model** from input data.
- The system uses the learned model to make useful predictions from new (never-before-seen) data drawn from the same distribution as the one used to train the model.
- Prediction at the **patient level** ,..., **voxel level**

Automated tissue classification



*Supervised kNN
tissue classification*

Manual labeling of data

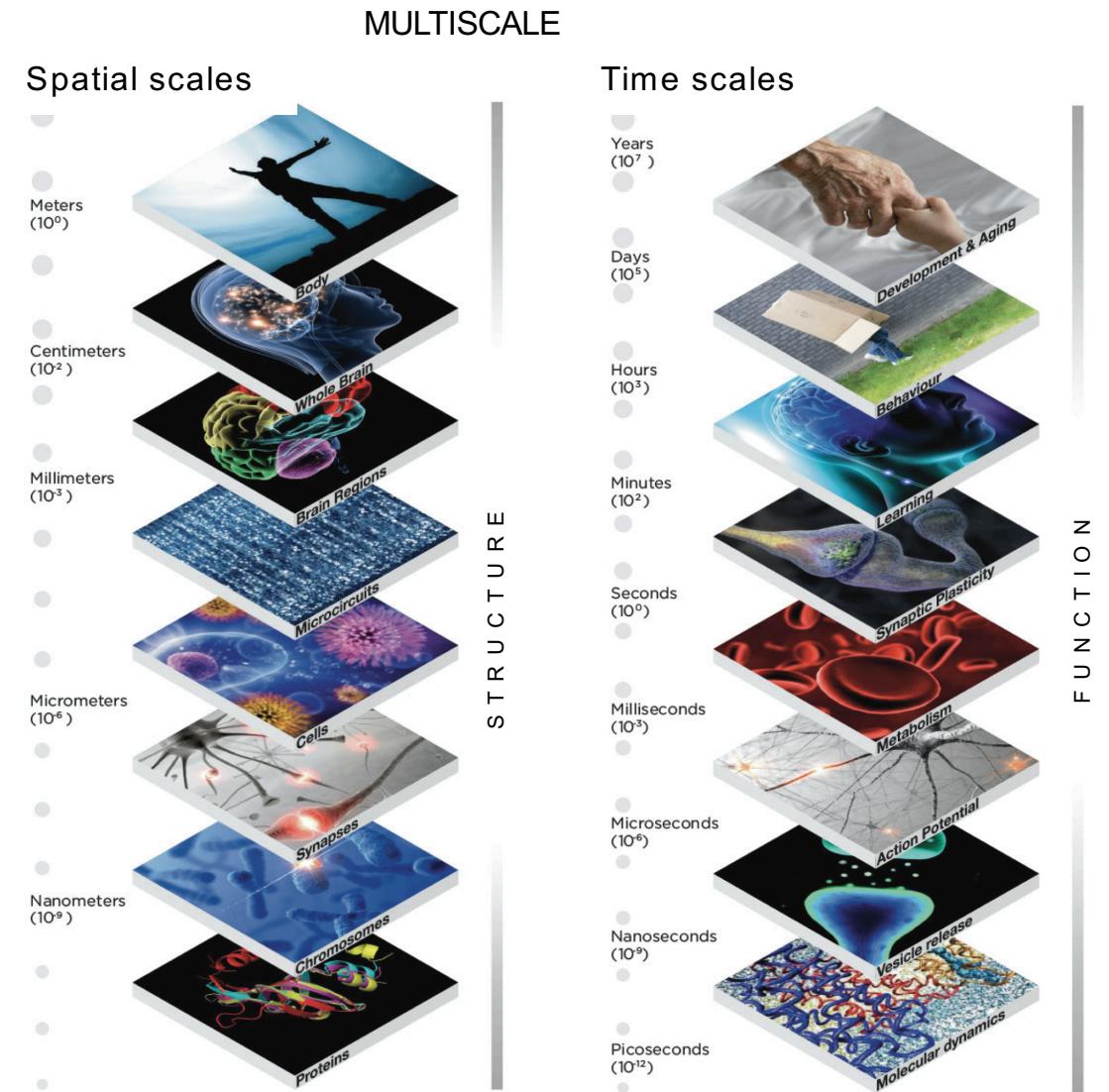
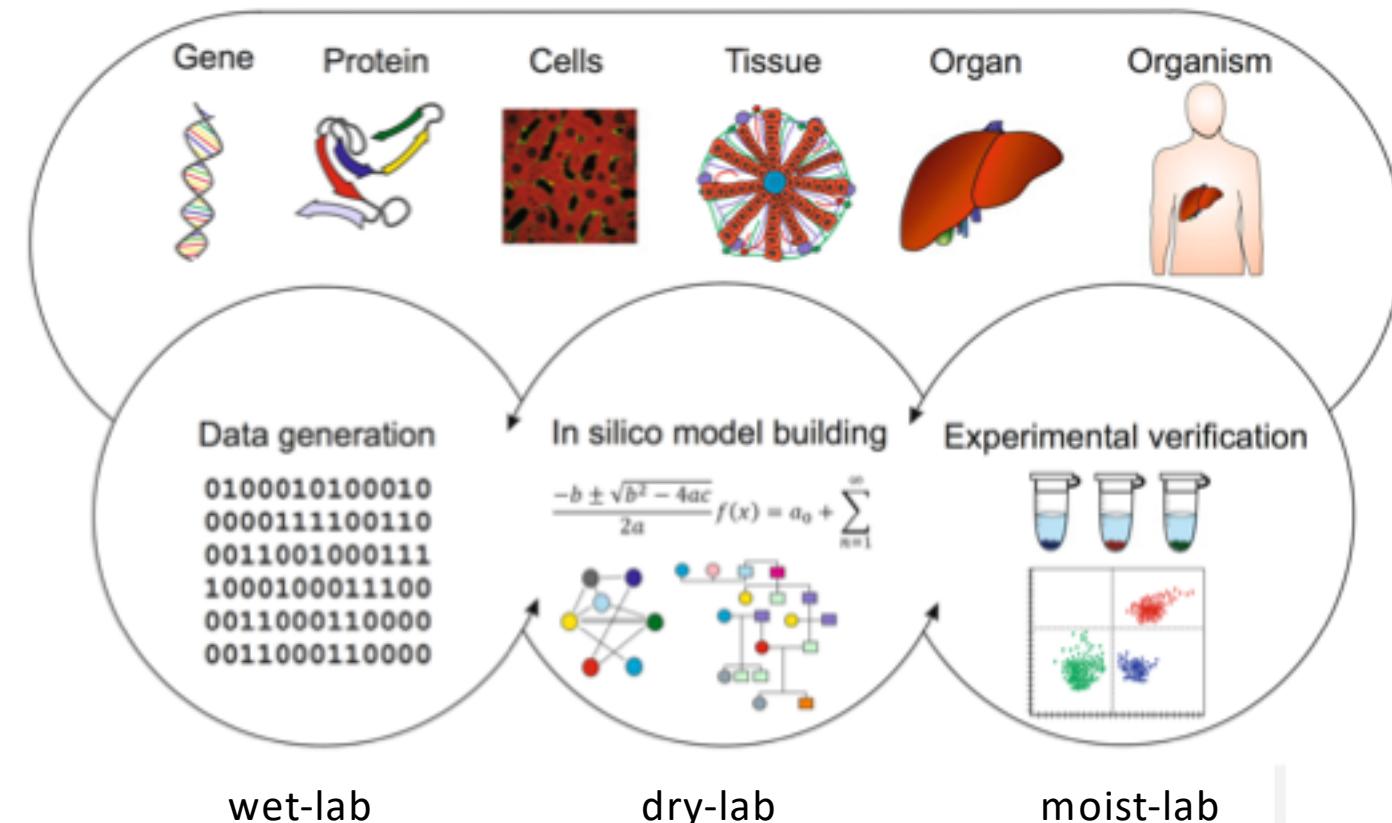


Precision Medicine

- **Integrating detailed patient information from multiple sources in a holistic manner**
- Biomedical imaging and imaging-guided interventions, which provide **multiparametric morphologic and functional information** and enable focused, minimally invasive treatments, are key elements in the infrastructure needed for PM

Systems medicine and computational imaging

→ precision medicine

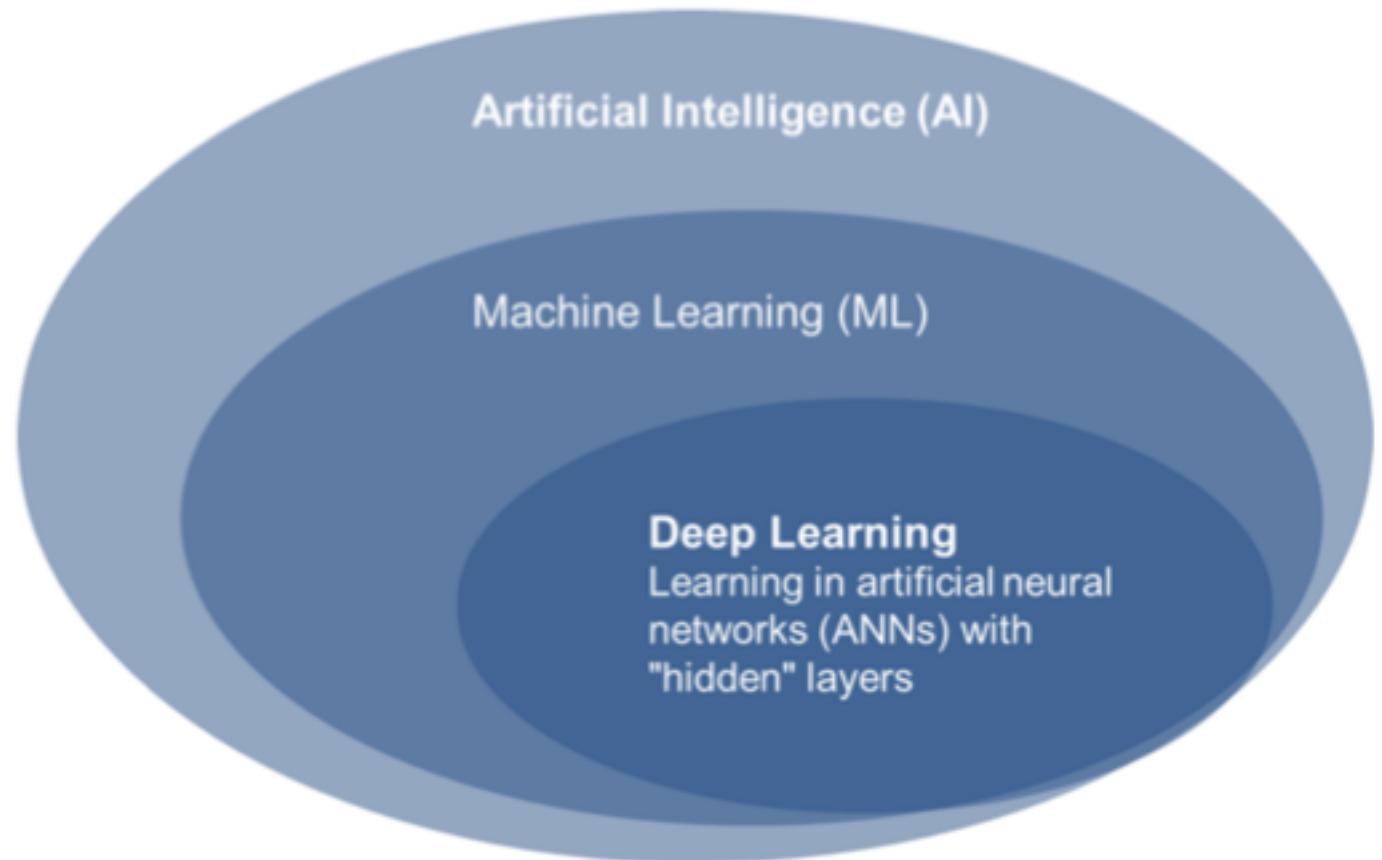


Computational science

Data Science

Machine Learning

Artificial Intelligence

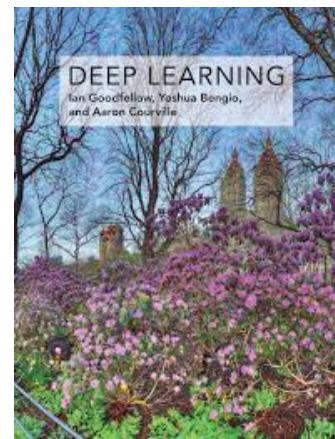


Computational science `producing governing equations'
e.g. tumor growth

Data Science `producing insights'
e.g. explorative and longitudinal data analysis

Machine Learning `producing predictions'
Machine Learning (ML)
e.g. biomarkers → treatment response

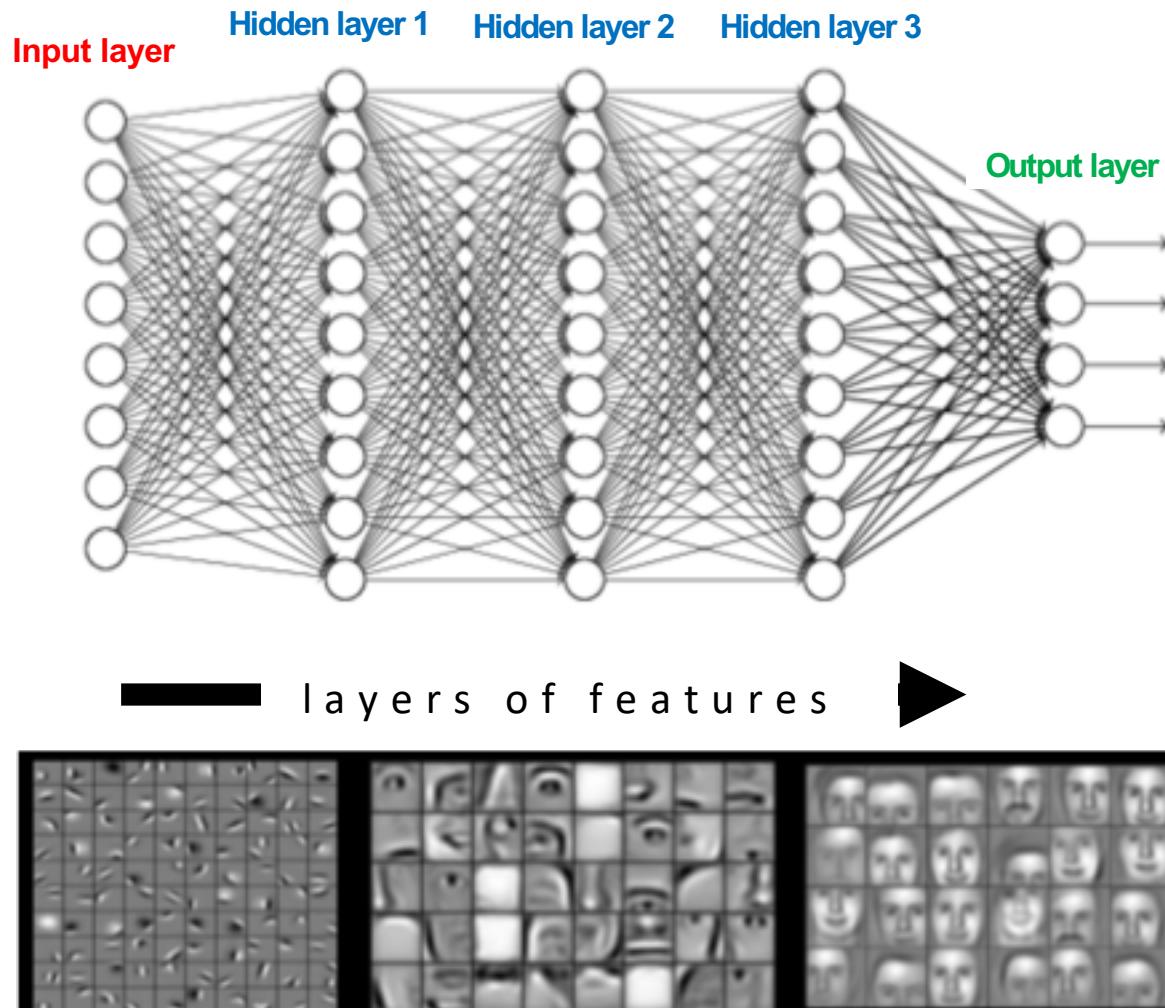
Artificial Intelligence `producing actions'
Deep Learning
Learning in artificial neural networks (ANNs) with
e.g. imaging-guided robot surgery



DEEP LEARNING MODELS

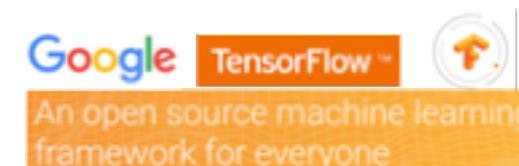
... engineered systems inspired by the biological brain

Neural networks - deep learning

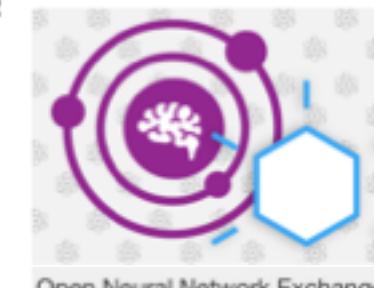


Deep learning is a branch of machine **learning** based on a set of algorithms that attempt to model high-level abstractions in data by using multiple processing layers, with complex structures or otherwise, composed of multiple non-linear transformations

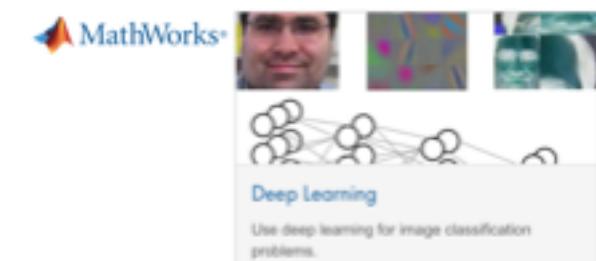
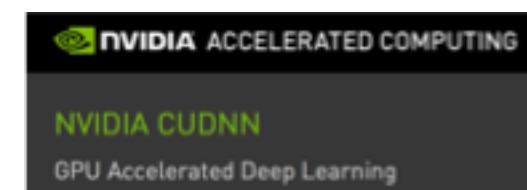
Wikipedia



Facebook and Microsoft collaborate to simplify conversions from PyTorch to Caffe2

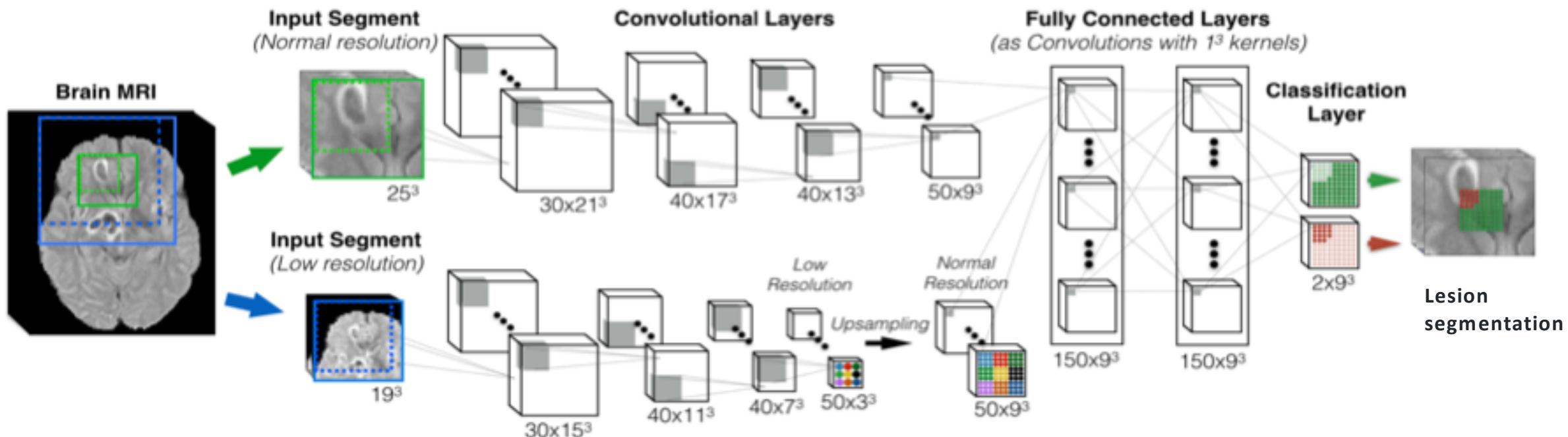


Open Neural Network Exchange



By training thousands of connections (“synaptic weights”) the multilayer deep neural network will learn brain anatomy at many spatial scales

A double-pathway architecture for multi-scale processing



At each layer, the number and size of feature maps (FMs) is depicted in the format (*Number-Of-FMs x Dimensions*).

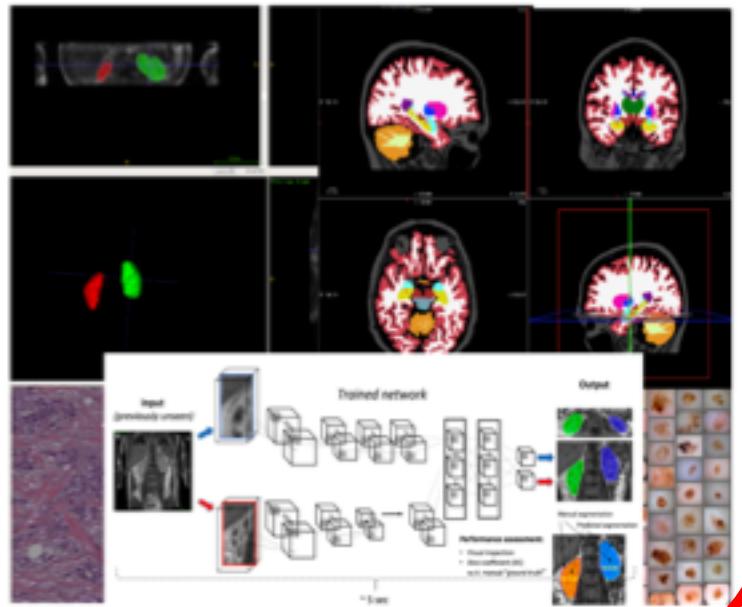
<https://github.com/Kamnitsask/deepmedic>

The Mohn Medical Imaging and Visualization Centre

Computational medical imaging and machine learning – methods, infrastructure and applications

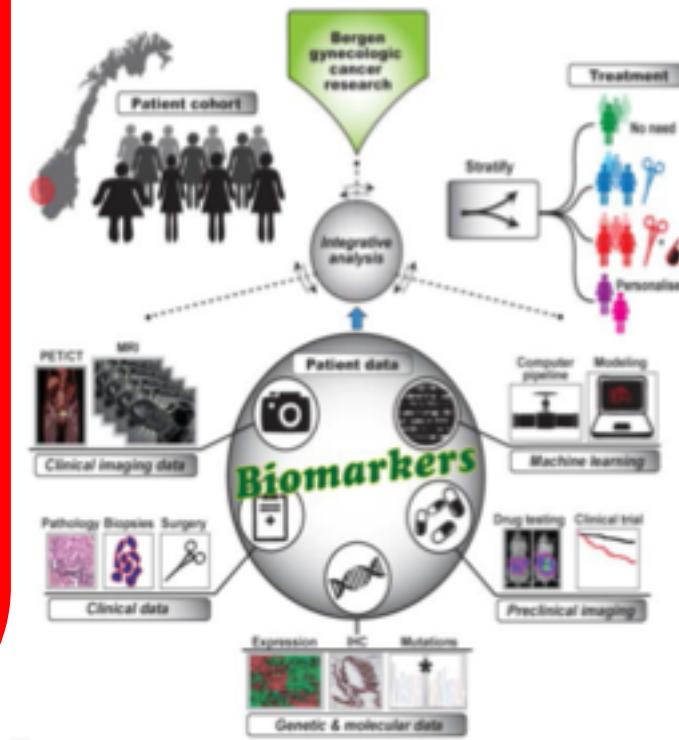
– A collaboration between the [Department of Biomedicine](#), UiB, and the [Department of Computing, Mathematics and Physics](#), HVL

<https://mmiv.no/machinelearning>

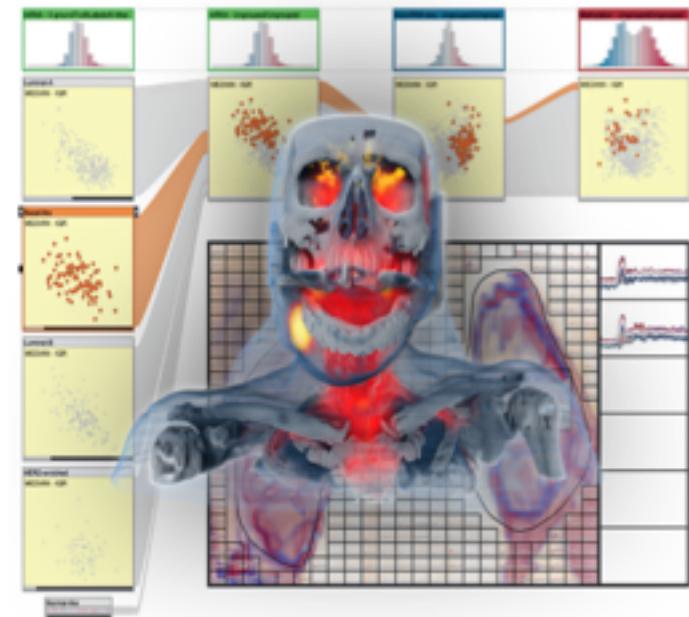


Centre projects

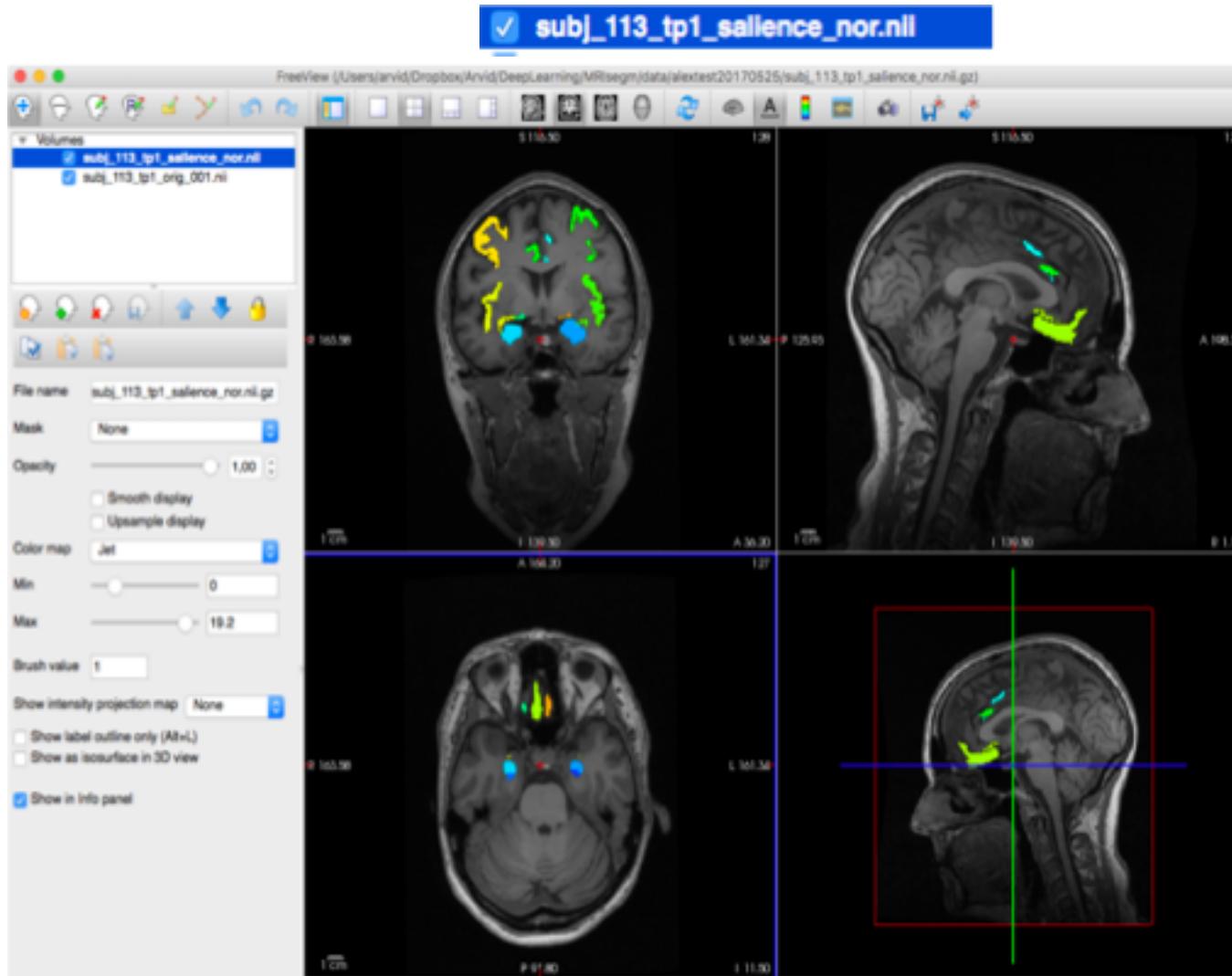
Precision imaging in gynecologic cancer



Visual Data Science for Large Scale Hypothesis Management in Imaging Biomarker Discovery



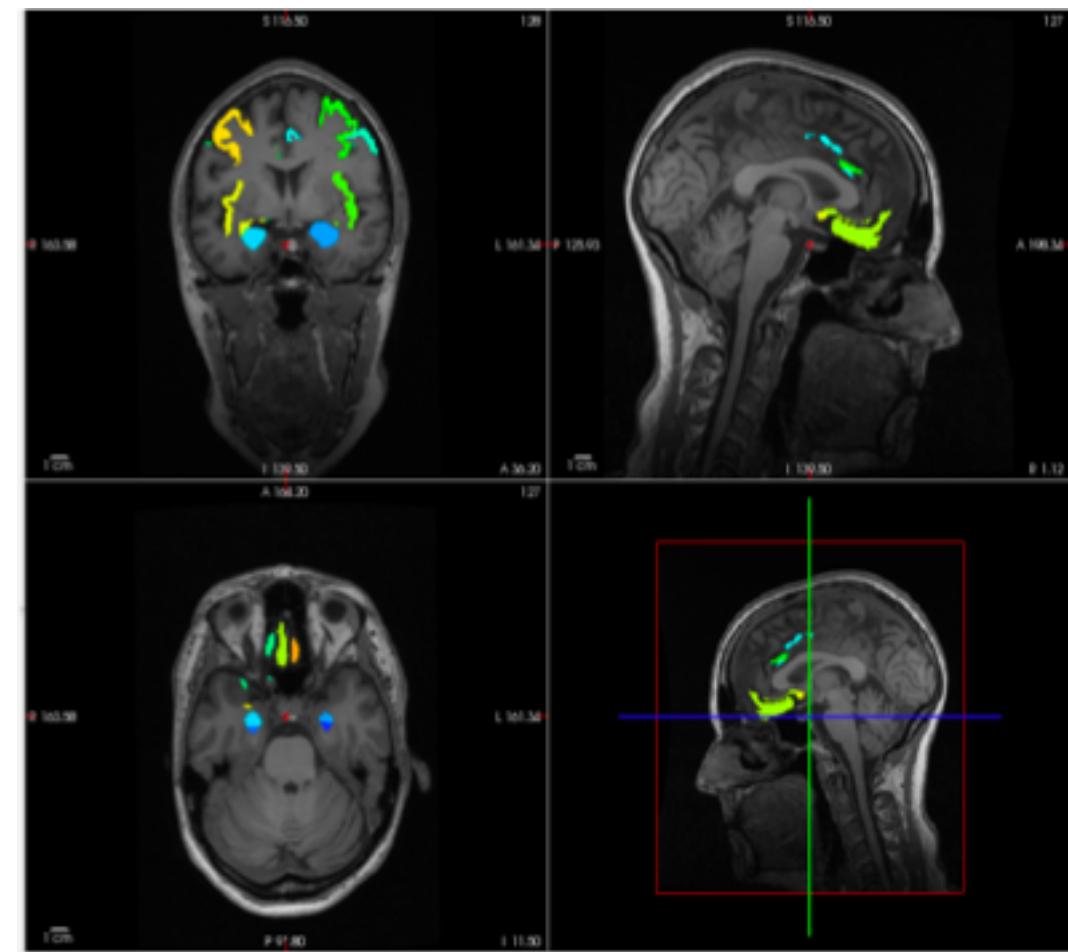
Training the CNN takes many hours to several days, dependent on number of training sets, networks architecture and hardware (GPUs)



Freesurfer 6.0 (“ground truth”)

~10 hr processing time

✓ subj_113_tp1_org_001_nor_Segm.nii

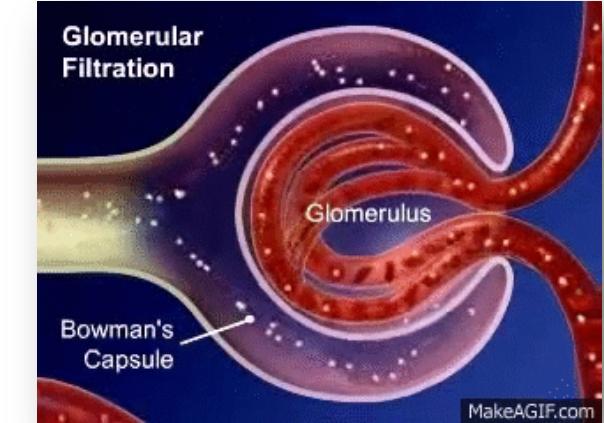
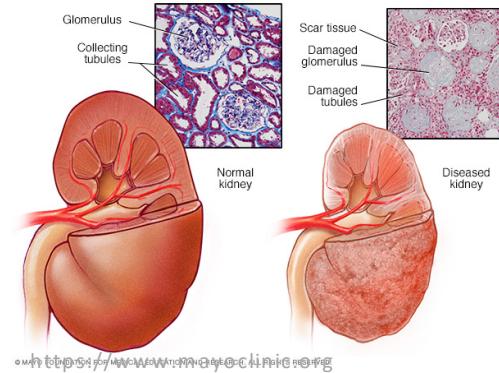


Deep learning (CNN)

~1 min classification time !

Chronic kidney disease ↑

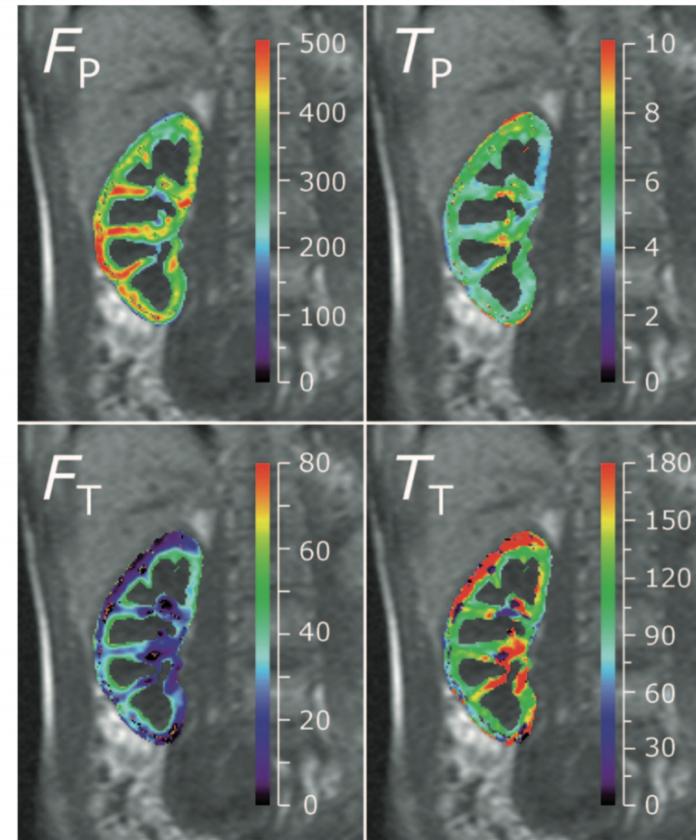
Diabetes, hypertension, ...



Functional renal imaging DCE-MRI

Non-invasive estimation of local
glomerular filtration rate (GFR)

... will need fast image
segmentation of the kidneys



Sourbron et al. MRI-Measurement of Perfusion and Glomerular Filtration in the Human Kidney With a Separable Compartment Model. Investigative Radiology 2008;43:40-48.

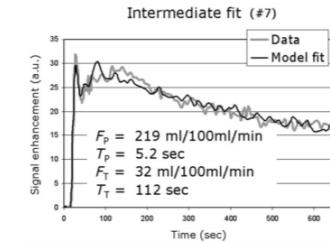
The four independent model parameters

$$F_p \text{ (mL/100 mL/Min)}$$

$$T_p = MTT_p \text{ (sec)}$$

$$F_t \text{ (mL/100 mL/Min)}$$

$$T_t = MTT_t \text{ (sec)}$$



for the data with the intermediate fit accuracy

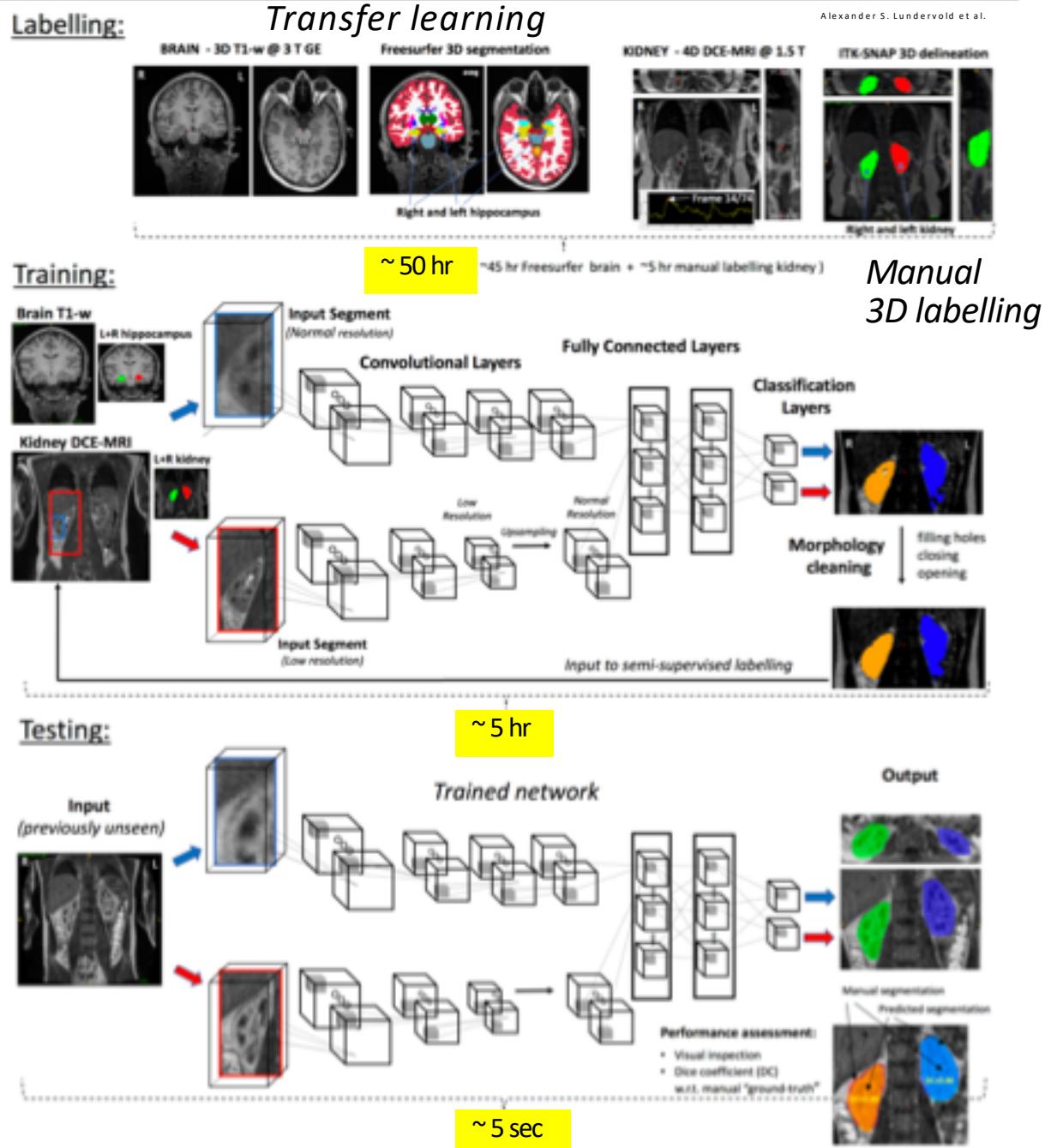
Image-derived biomarkers

The cortex region was defined retrospectively as those pixels with $V_p > 20 \text{ mL/100 mL}$.

The parametric maps (colored) are superposed on a precontrast image (gray) for anatomic reference.

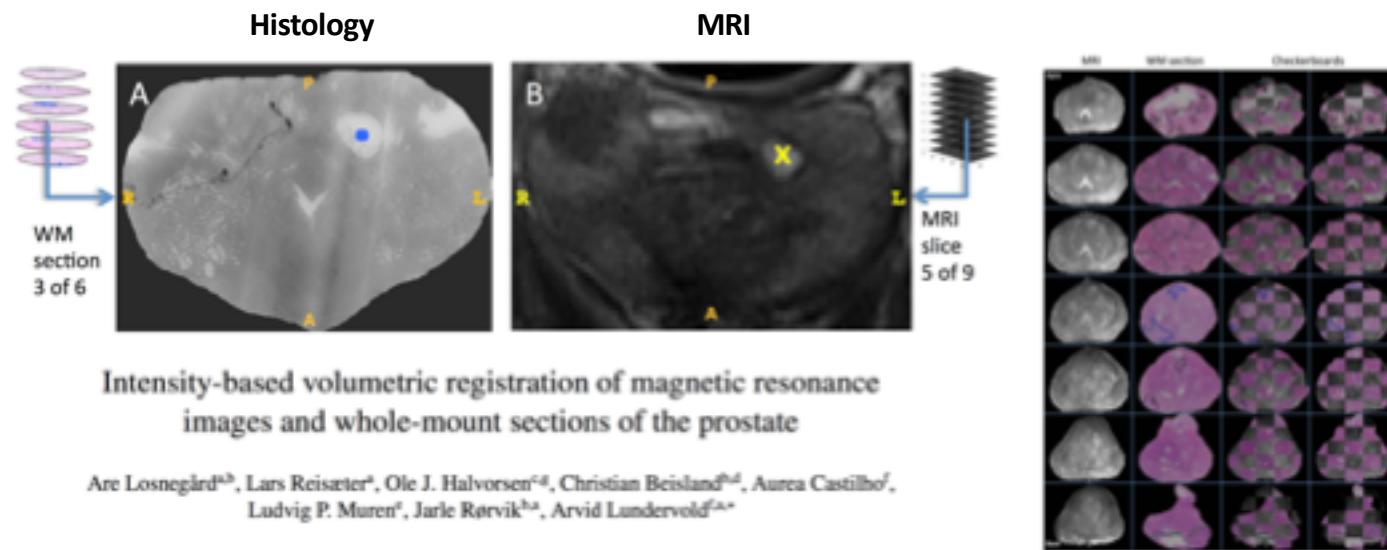
Fast semi-supervised segmentation of the kidneys in DCE-MRI using convolutional neural networks (CNN) and transfer learning (hippocampus)

A. S. Lundervold, J. Rørvik, A. Lundervold
Functional Renal Imaging: Where Physiology, Nephrology, Radiology and Physics Meet, Berlin 2017



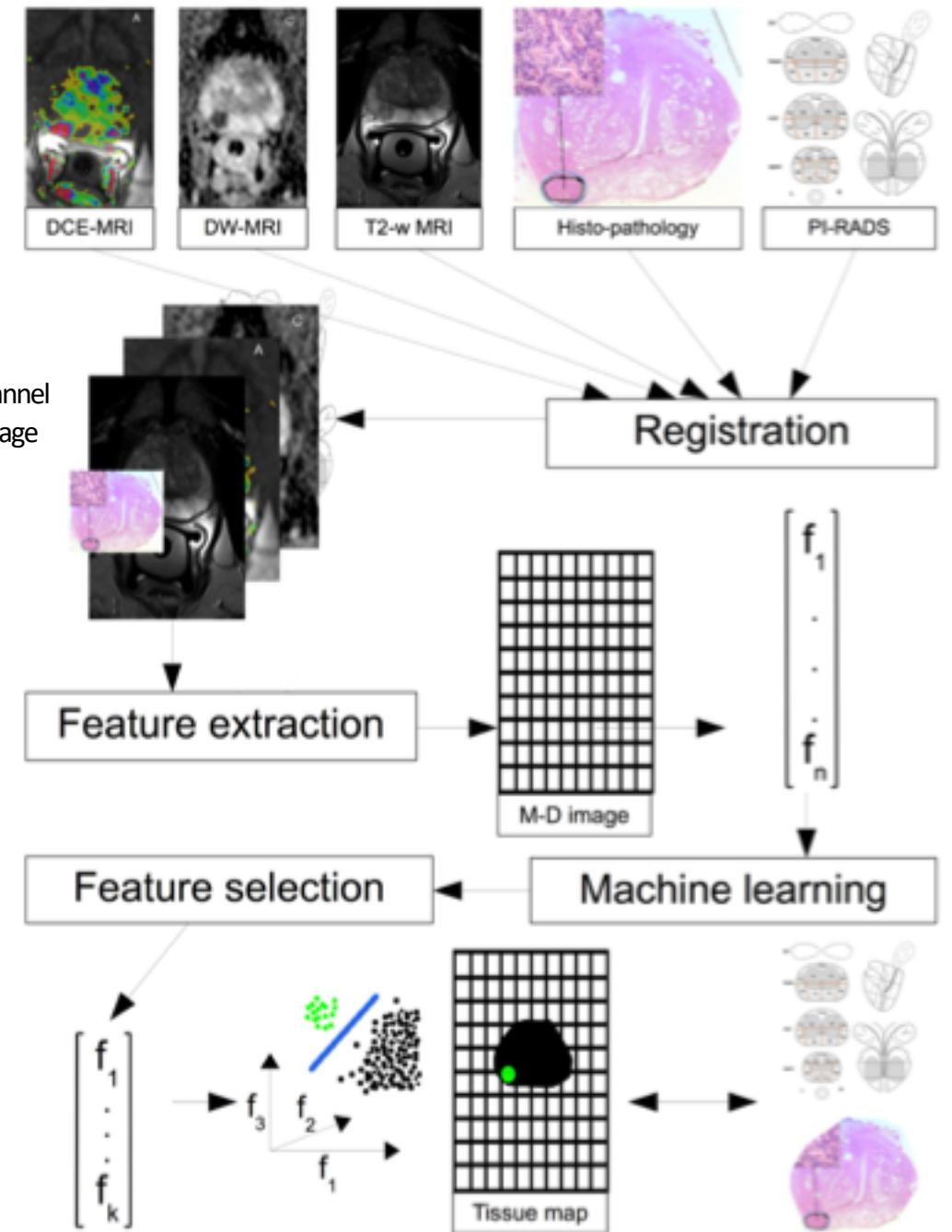
Prostate cancer

- Multi-parametric MRI and histopathology
- From digital pathology to computational pathology



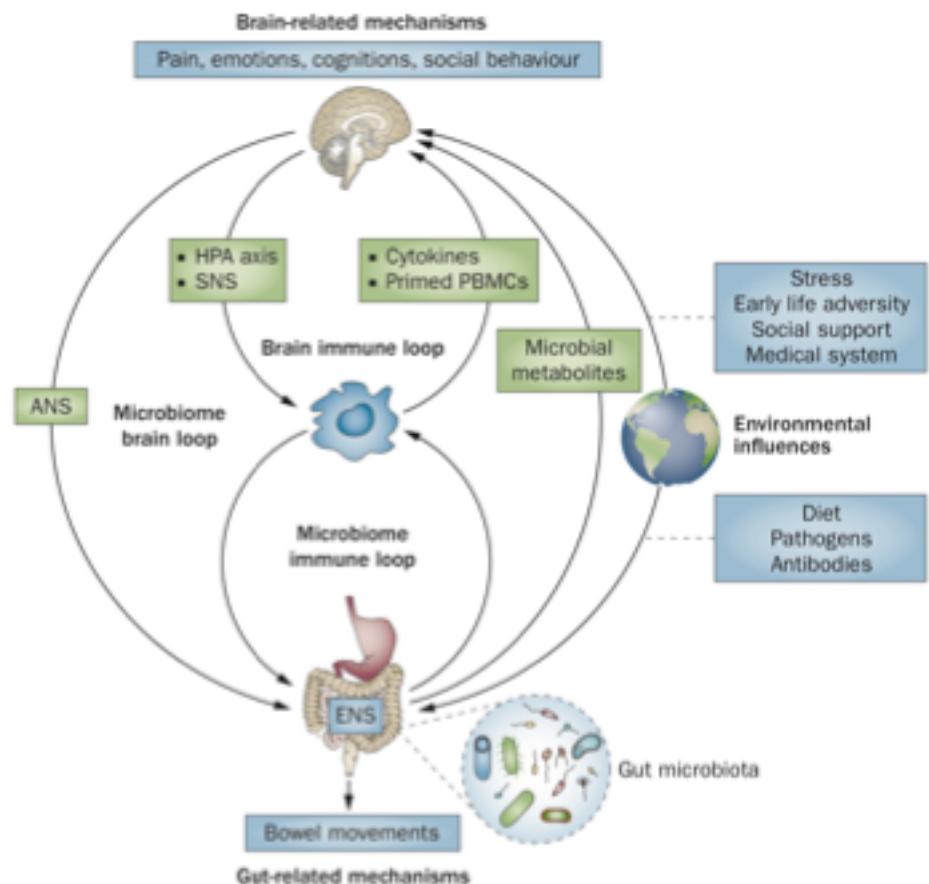
Are Losnegård^{a,b}, Lars Reiseter^a, Ole J. Halvorsen^{c,d}, Christian Beislund^{b,d}, Aurea Castilho^f, Ludvig P. Muren^e, Jarle Rørvik^{b,a}, Arvid Lundervold^{d,a,*}

Computerized Medical Imaging and Graphics 63 (2018) 24–30



Neuro-gastroenterology

Brain-gut axis and prediction of IBS from sMRI, dMRI, and resting-state fMRI

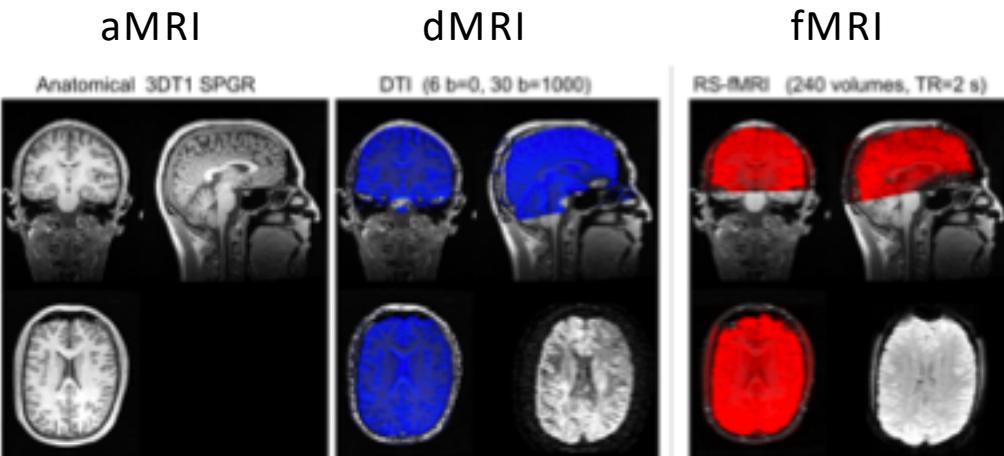


Eman A. Mayer, Jennifer S. Labus, Kirsten Tillisch, Steven W. Cole and Pierre Baldi

Nat. Rev. Gastroenterol. Hepatol. 12, 592–605 (2015)

Pre-intervention
scans:

(1) →



Intervention:

(2) →



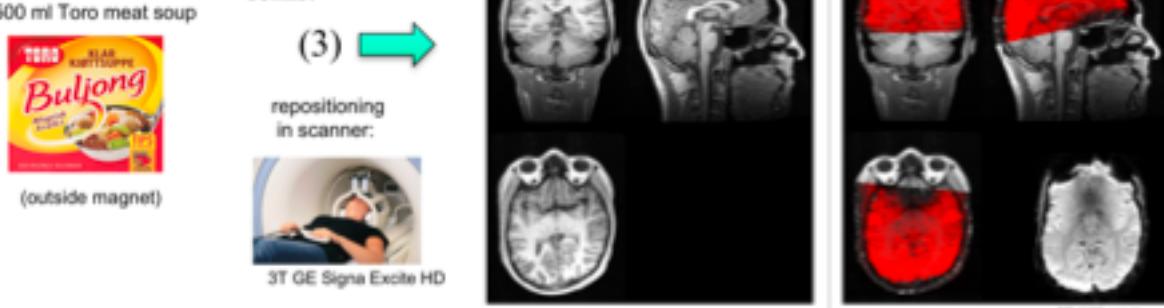
Post-intervention
scans:

(3) →

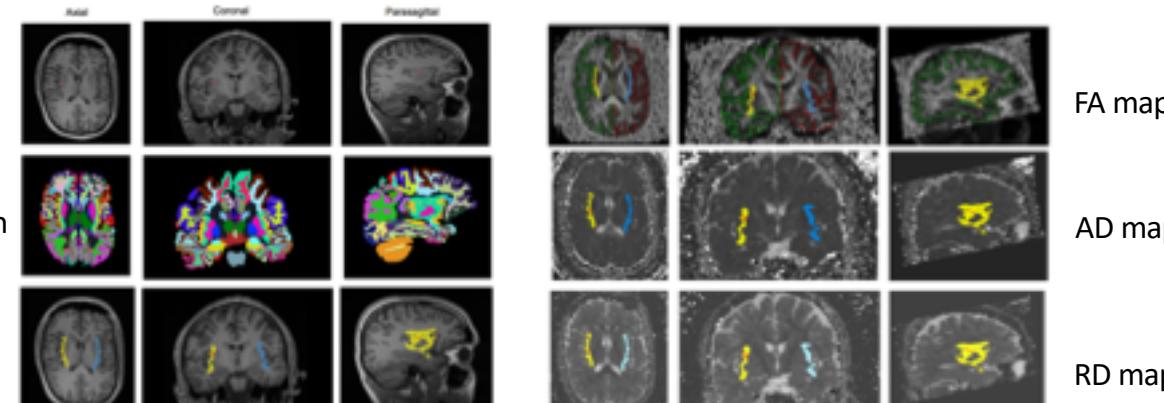


Anatomical 3DT1 SPGR

RS-fMRI (240 volumes, TR=2 s)



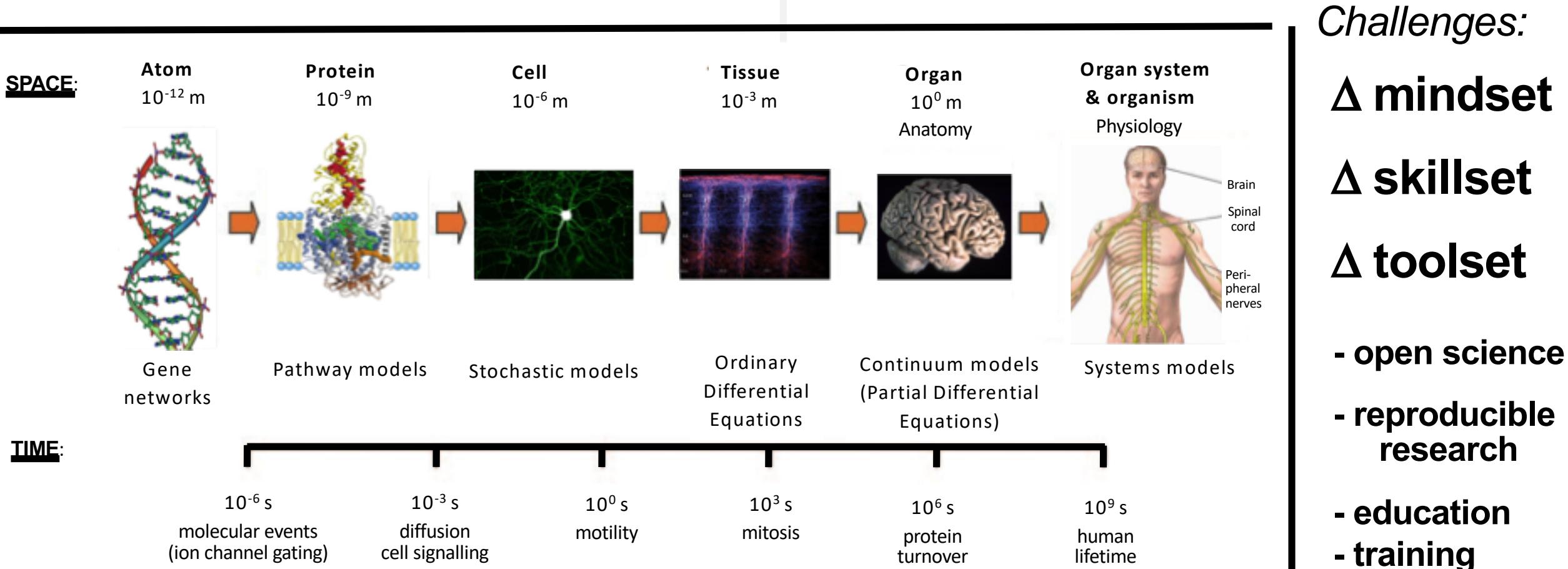
Freesurfer 6
segmentation



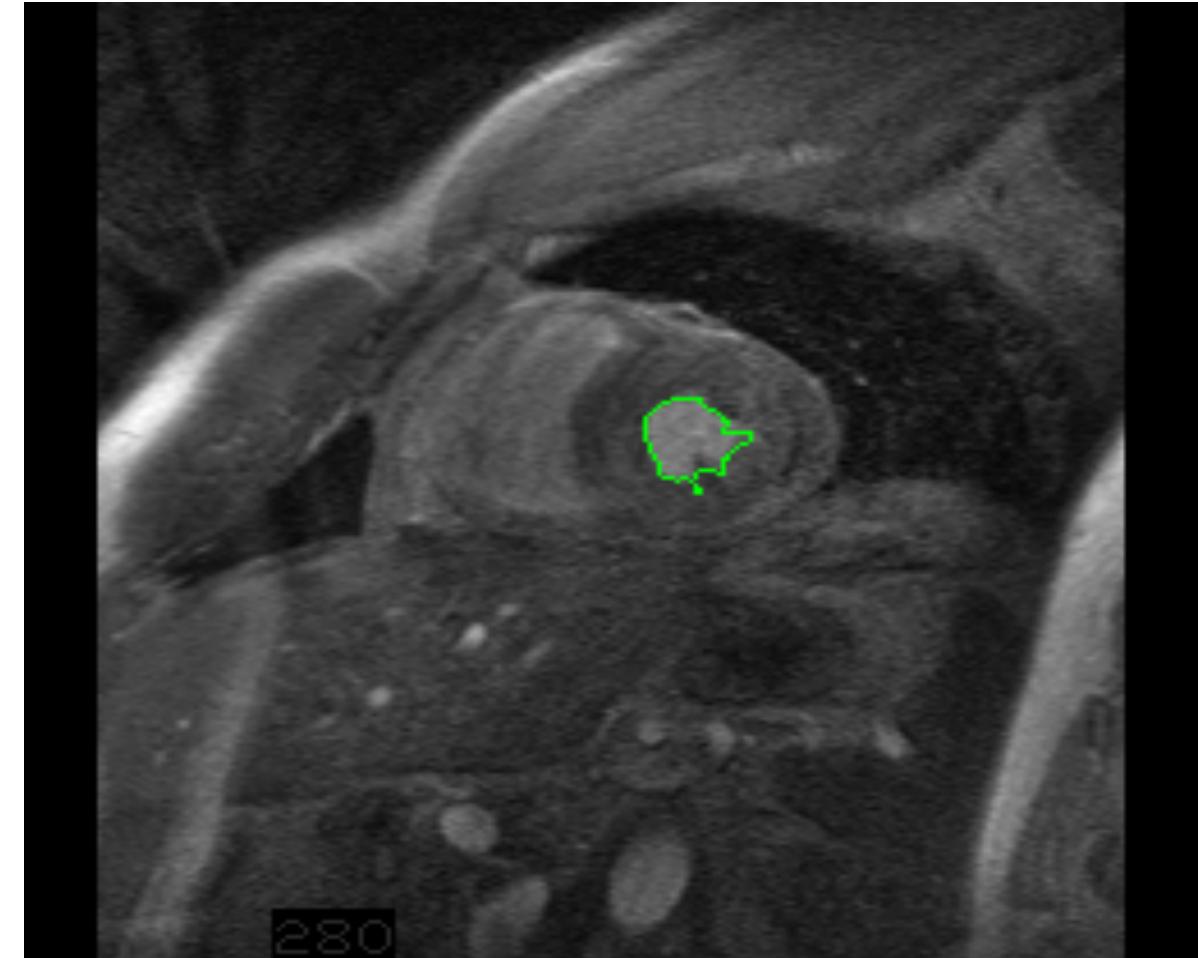
Insula /
salience
network

The future of (bio)medical imaging and precision medicine ...

- **MULTIMODAL IMAGING + OMICS + SYSTEMS BIOLOGY / SYSTEMS MEDICINE**
- **TRANSDISCIPLINARITY and COMPUTATIONAL APPROACHES [ML]** to the assess and predict the multi-scale nature of molecules (-omics), cells, tissues and organs in health and disease



Thanks !



The challenge of imaging, precision and decision in society and in medicine

Computational medicine

- A new field of science, which embraces mathematics, physics, information technology, biomedical engineering, and medicine ...
... to collect, manage, mine, analyse and visualise a very heterogeneous mixture of data like personalised genetic and proteomic profiles, bio-signals and the monitoring of movement, advanced imaging, and other relevant phenotype information in such a way that useful clinical information for improving human health can be extracted.”

– M. Daumer, SLCMSR / Munich&Cambridge International School for Clinical Bioinformatics and Technical Medicine