AI FOR THE INTERPRETATION OF BIOMEDICAL IMAGING AND GENETIC DATA
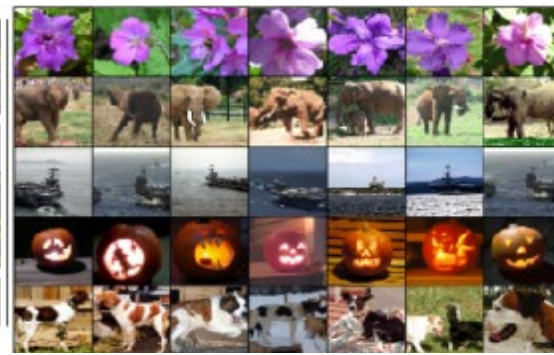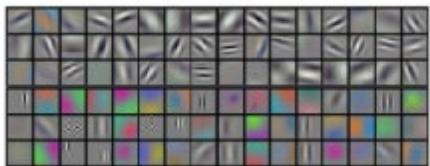
OPPORTUNITIES AND CHALLENGES TO TRANSLATE TO CLINICAL PRACTICE

Wiro Niessen
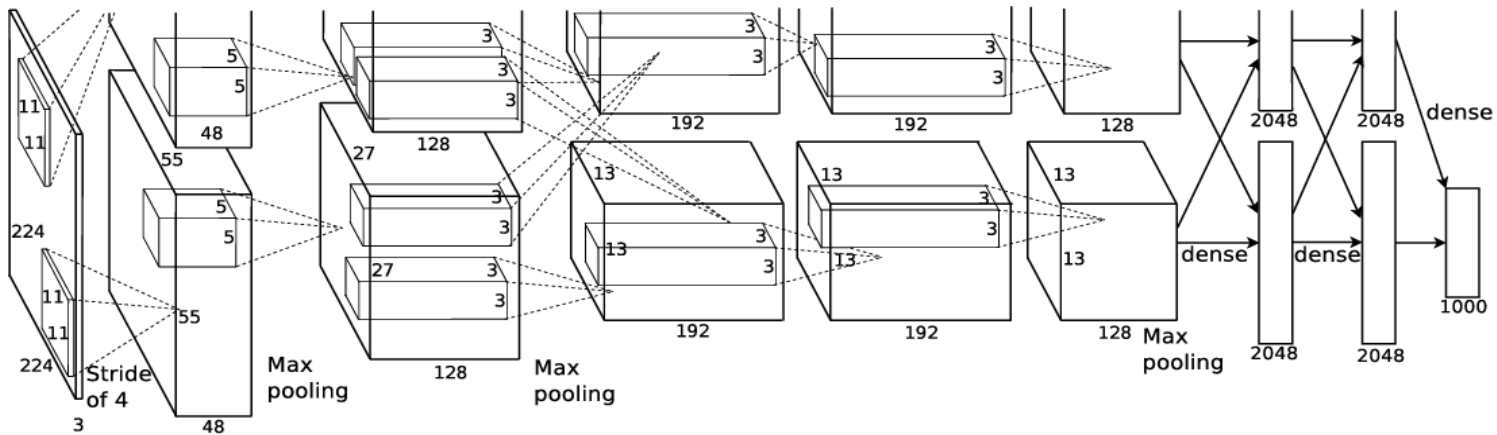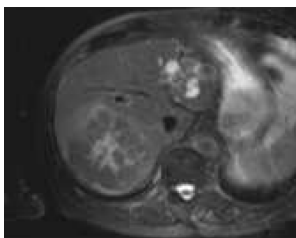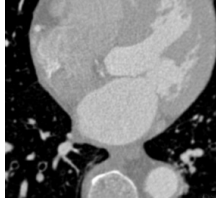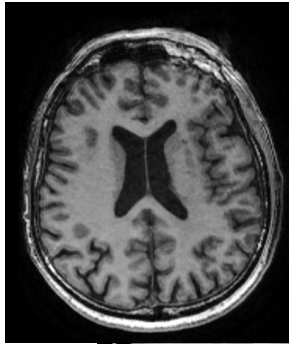
Erasmus MC & TU Delft

Quantib BV (disclosure)

Erasmus MC
University Medical Center Rotterdam

ImageNet 2012: Image classification breakthrough with convolutional neural nets
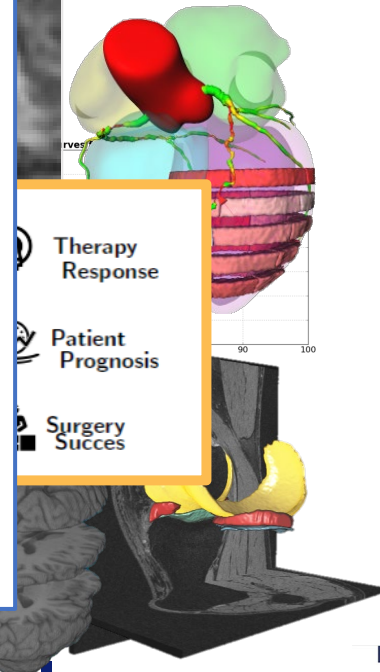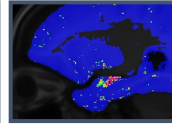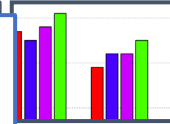
Can this success be translated to clinical practice?

Specific health domain challenges:

- We need to do to more than image perception.

- We need to collect more than images alone (genetics, omics, clinical information, exposome).

- Human biology and pathology is highly variable.
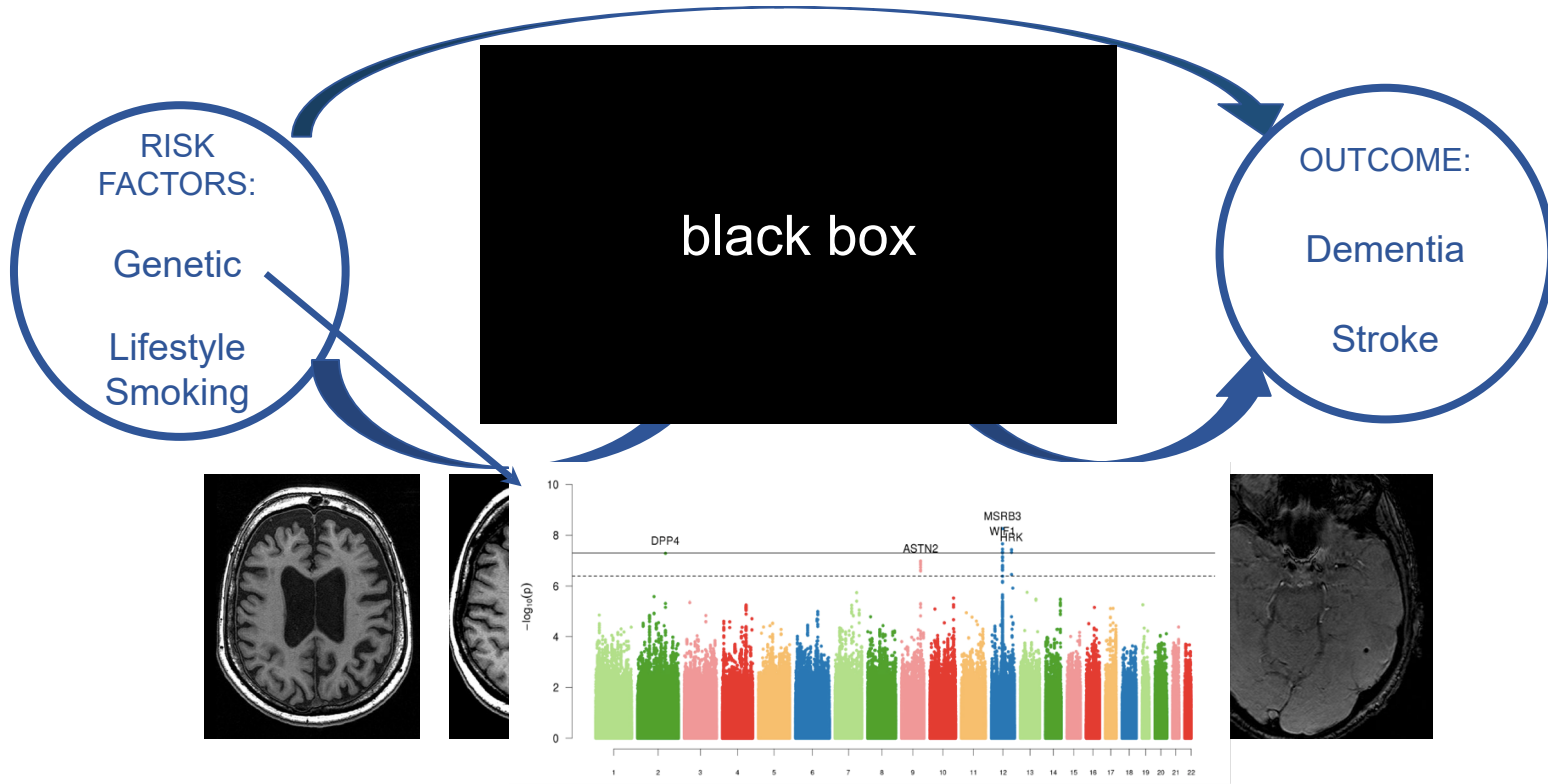
- Data bias is a challenge

Therapy Response

Patient Prognosis

Surgery Succes

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Population imaging: Rotterdam Study

- Population study running over 25 years

- \> 15.000 subjects included

- Extensive geno- and phenotyping (imaging) available

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Population imaging: design

Rotterdam Scan Study (> 15.000 brain MRI) library of quantitative imaging biomarkers
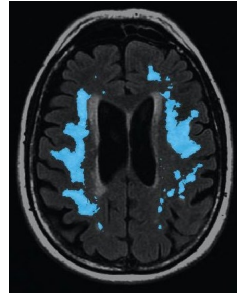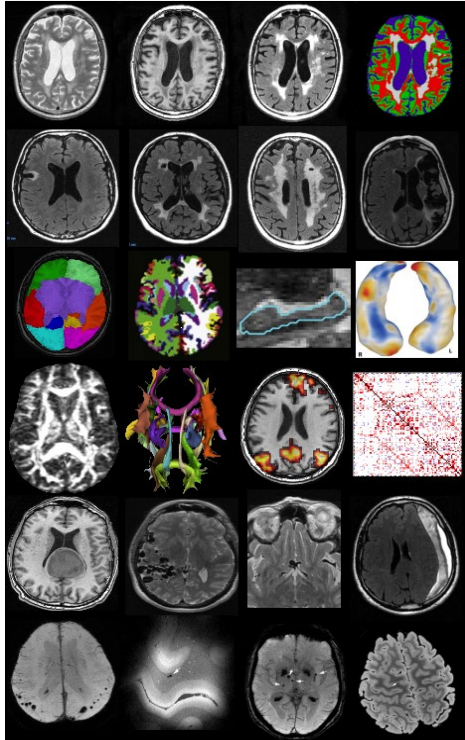
Brain tissue

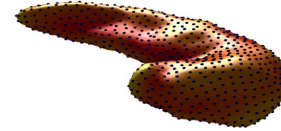White matter lesions

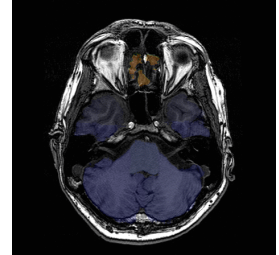Brain structures

Microstructure

Incidental findings

Micro bleedings

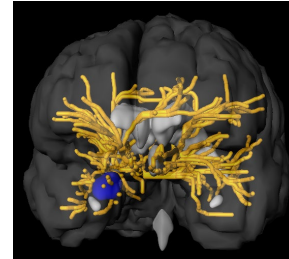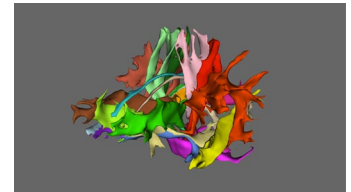Subcortical WML

Hippocampal shape and volume

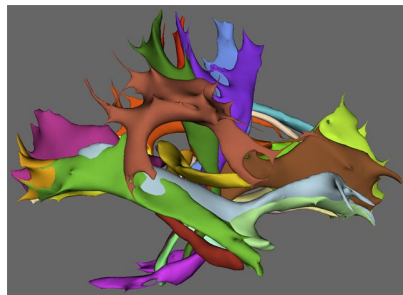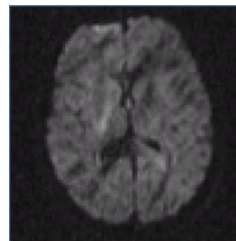Structural connectivity

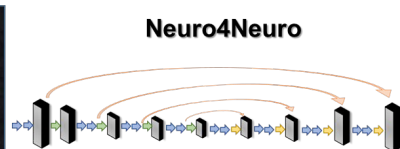Brain structures

White matter tracts

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White matter tract segmentation

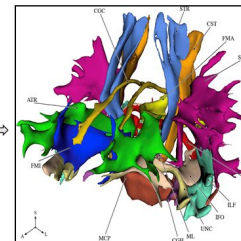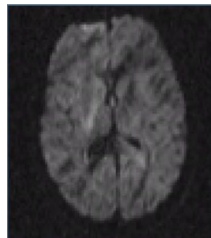**Diffusion tensor**

Neuro4Neuro

WM neural tract

CNN network: 0.5s per tract

Diffusion tensor

Reconstruction Step 1

Streamlines
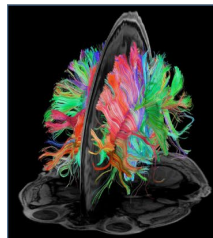
Clustering/Atlas Step 2

Step 3 Post-processing

Segmentation

Tractography and atlas-based segmentation
Minutes to multiple hours

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Clinical decision support

Quantib® ND*

Reference imaging
biomarker curves from
5.000 individuals of the
population-based
Rotterdam Scan Study

*FDA cleared and CE marked

Courtesy: Quantib

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Totally new imaging biomarkers

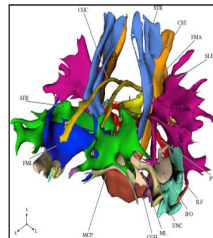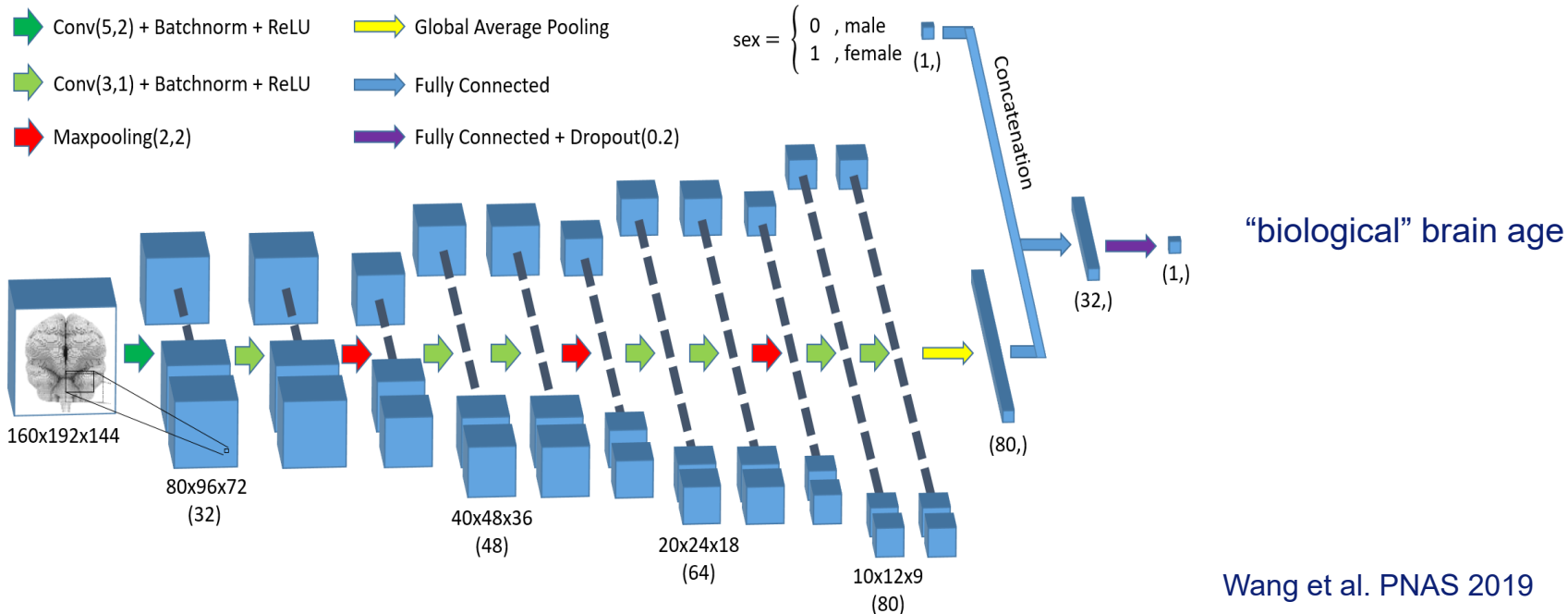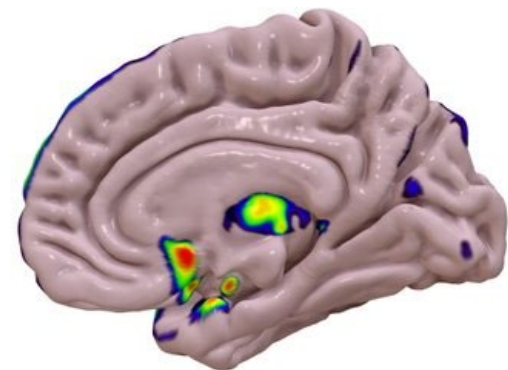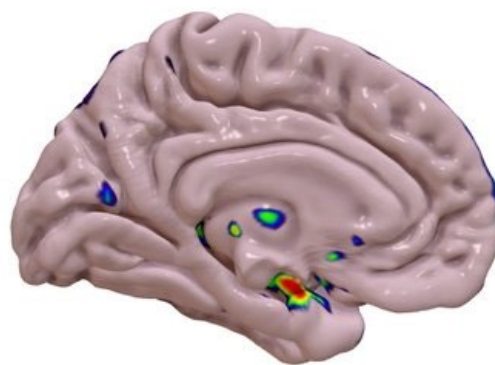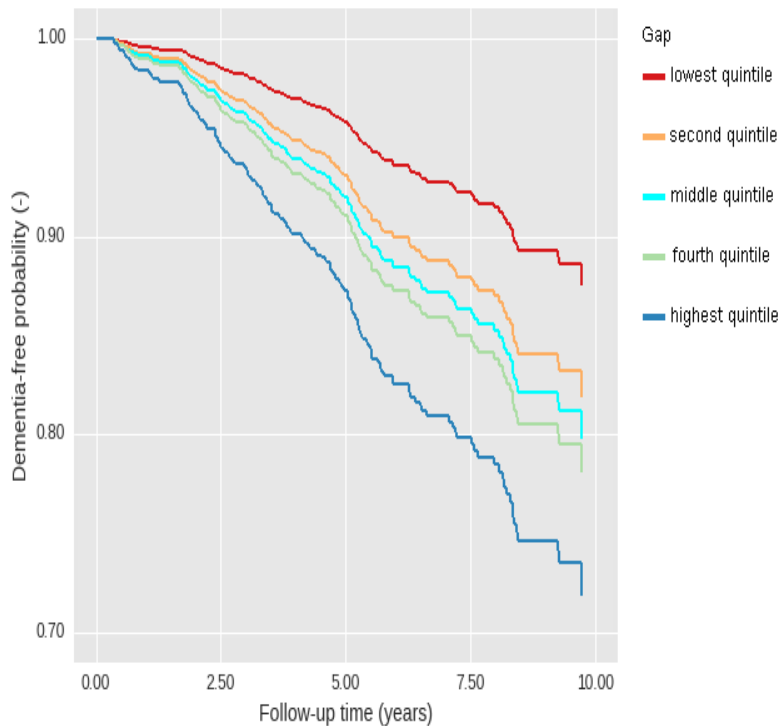Convolutional Neural Network architecture for brain age prediction (trained on 5865 images, tested on 2353)

Wang et al. PNAS 2019

Kaplan-Meier curves for new biomarker (delta brain / calendar age)

BEYOND IMAGING

MRI

Genetics

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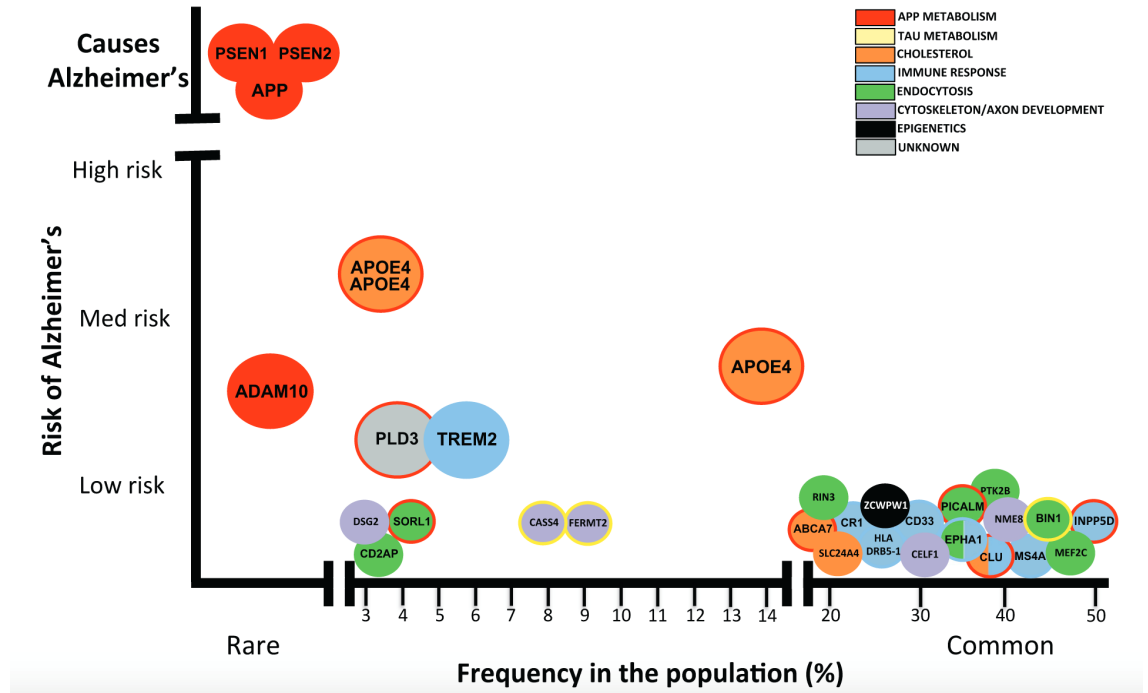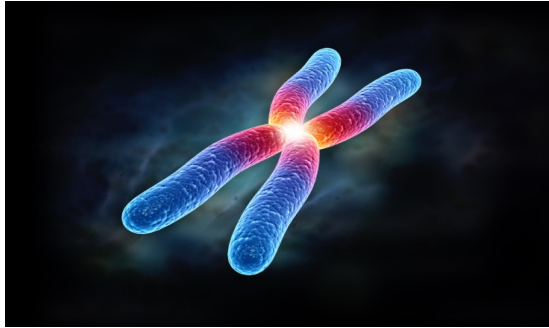
Population imaging genetics
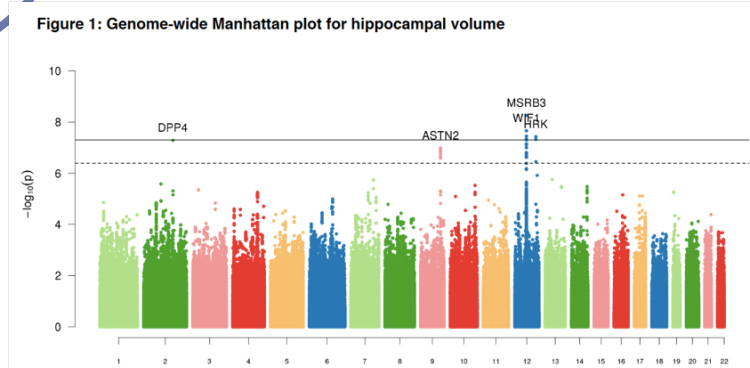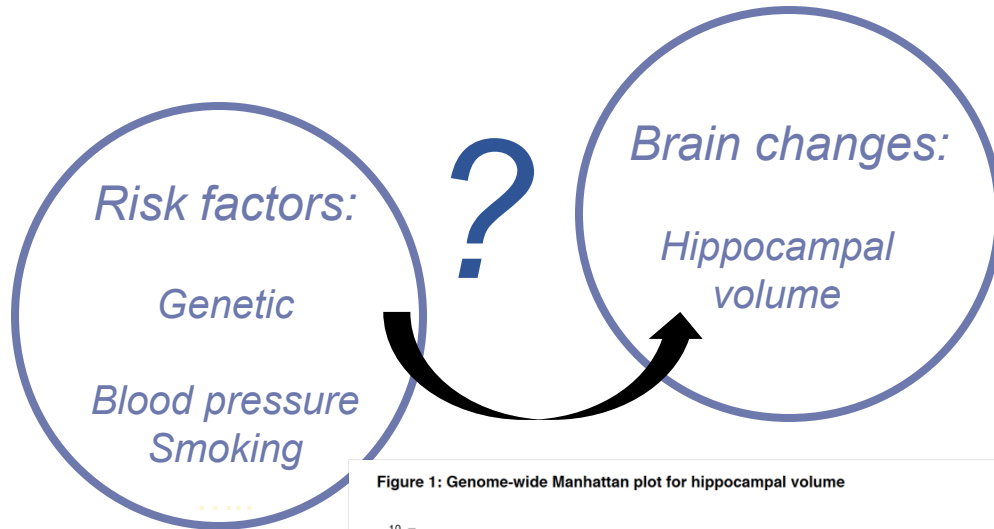
Imaging genetics: gaining insight in relation genetic liability, environmental factors and imaging phenotype

VBM analysis consisted of 4071 nondemented persons with information available on both genome-wide genotyping and MRI data from the population-based Rotterdam Study. The mean age was 64.7 (+/-10.7) years and 2251 (55%) subjects were women.

Roshchupkin et al. Neurobiology of ageing
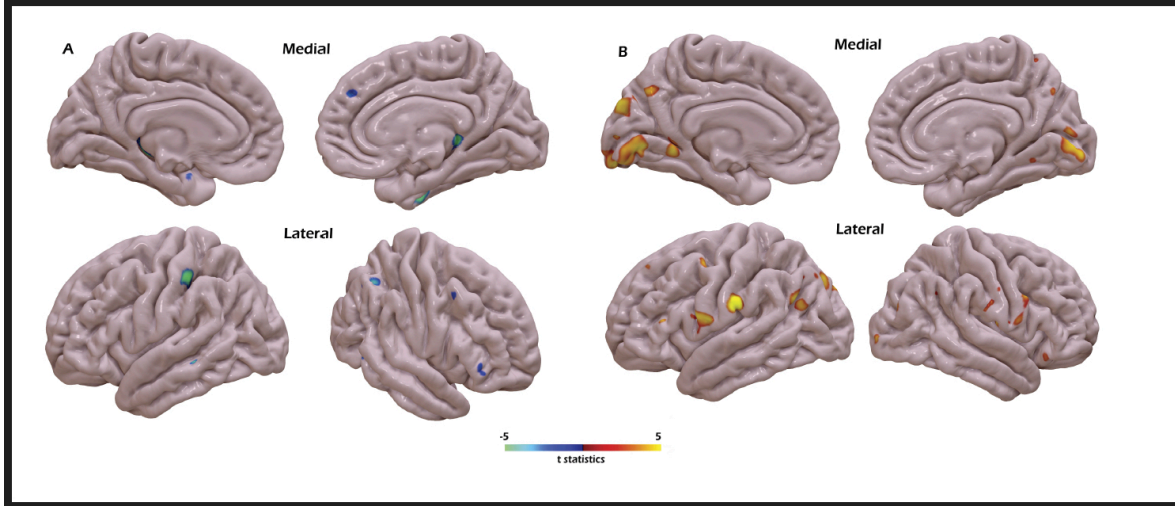
Neural Network - KEGG Pathway

DNA (1 200 000 SNPs)

Genes

Local pathways

Global pathways

Prediction
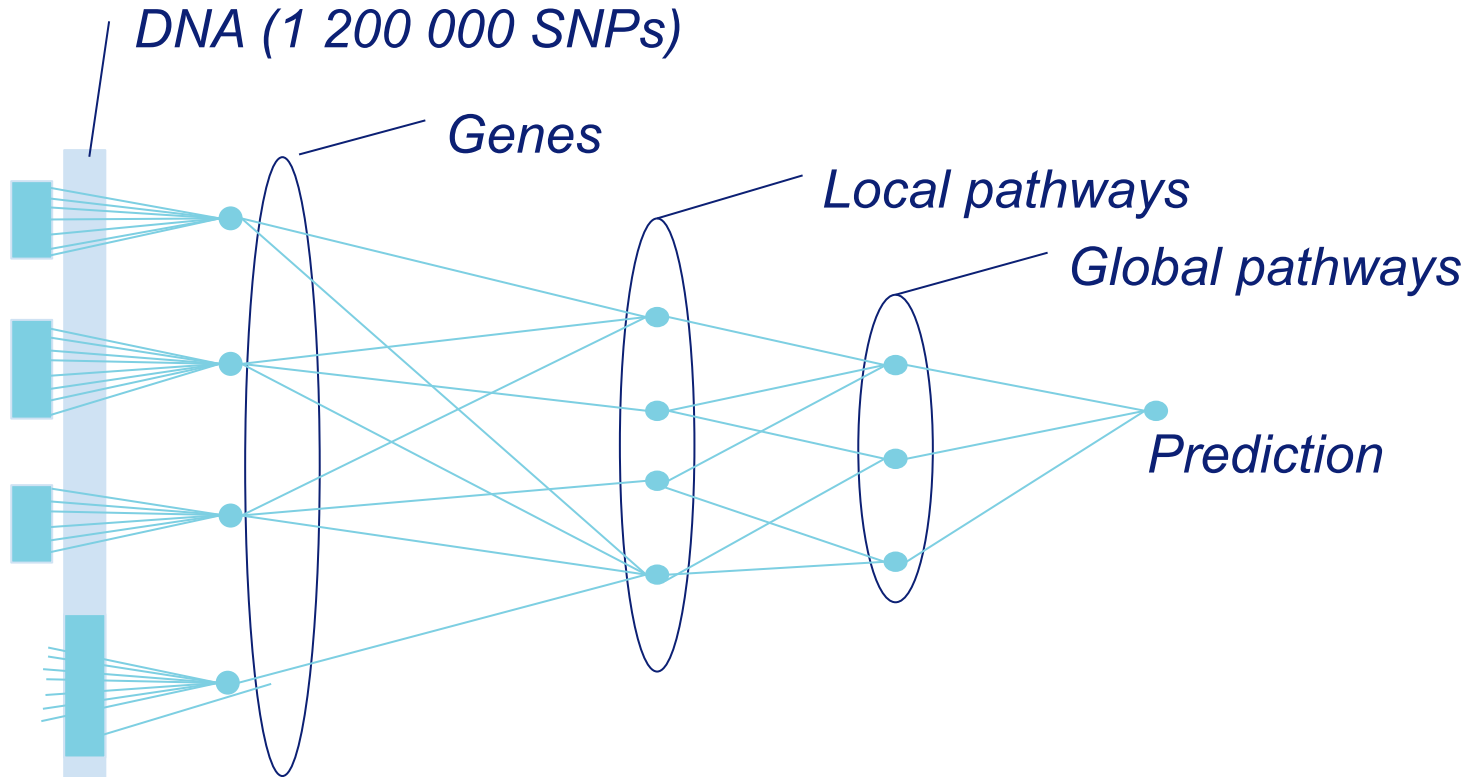
1,200,000 SNPs
to 21,390 genes
to 390 local pathways
to 43 pathways
to 6 global pathways
to 1 outcome

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Requirements successful introduction AI

- High quality data to train algorithms using state of the art algorithm optimization methods

- Clear definition of tasks and seamless integration into the workflow

- Proper validation strategies:

  Many promising algorithms may not function as well in clinical practice as reported in literature

  - Evaluation has been performed on retrospective data, often one or limited number of centers
  - Issues: data bias, lack of generalizability

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Data driven precision health requires health data infrastructure

health RI research infrastructure
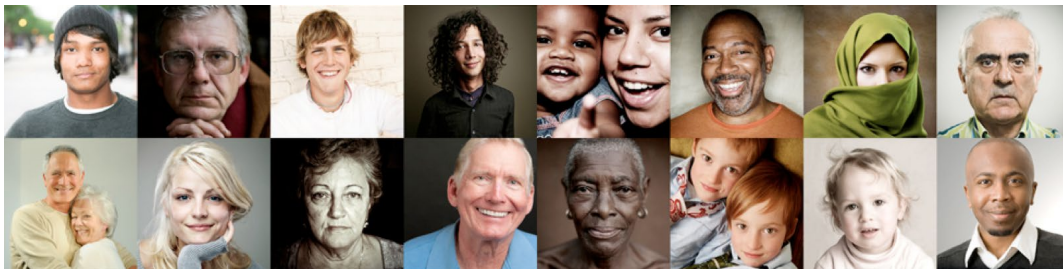
Taking individual variability into account to promote health, prevent & optimize diagnosis, prognosis and treatment

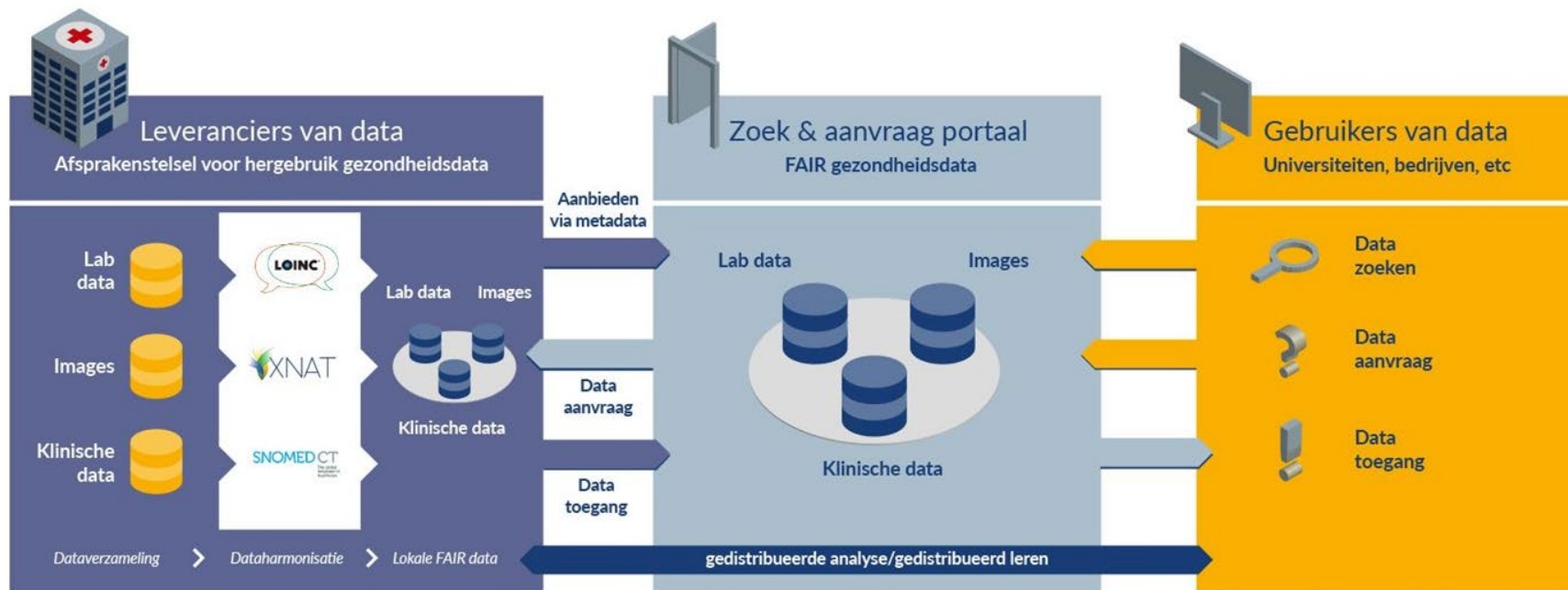**Utilizing our rich data resources and AI**

Anything you can do, AI can do better
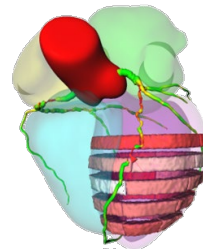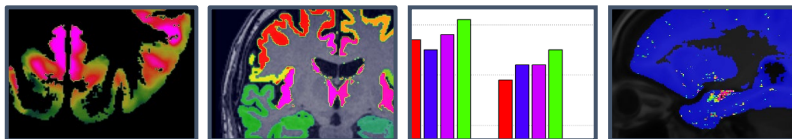
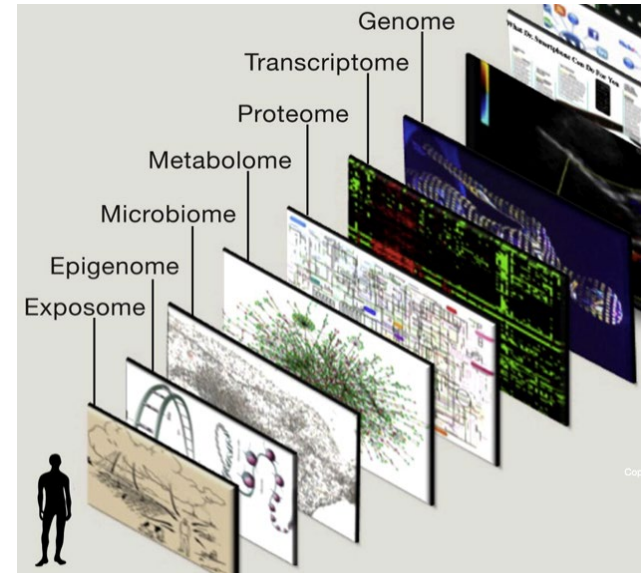Erasmus MC

Towards a national COVID-19

Future of healthcare is a learning healthcare system

What is needed?

- Work on higher quality and better accessible (image) data for science and innovation

- Implement FAIR data, distributed access and Open Science

- Create ML/DL challenges for important tasks

- Prospective validation for responsible introduction AI

Thank you