SCIENCE
UNIVERSITY OF COPENHAGEN

AI in Health

with examples from radiology

Mads Nielsen

Prof. PhD, Chair of Department of Computer Science, UCPH
Founder SCIENCE AI Centre, Biomediq A/S, Cerebriu A/S

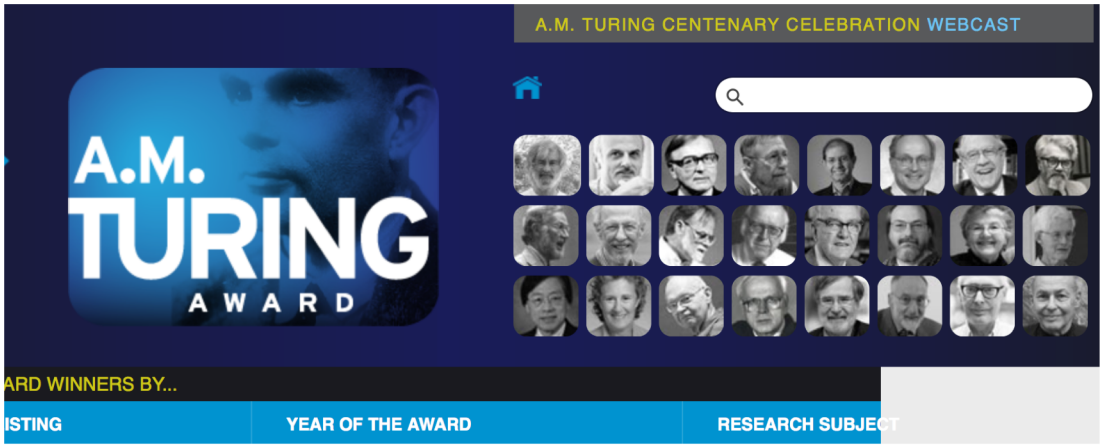
Department of Computer Science

2014: ACM lifetime achievement award to Neil D Jones

2008-12: New Interdisciplinary curricula in health, communication, and cognition

2005: Turing award to Peter Naur

1970: Founded with curricula in Computer Science.
Peter Naur first Head of Department



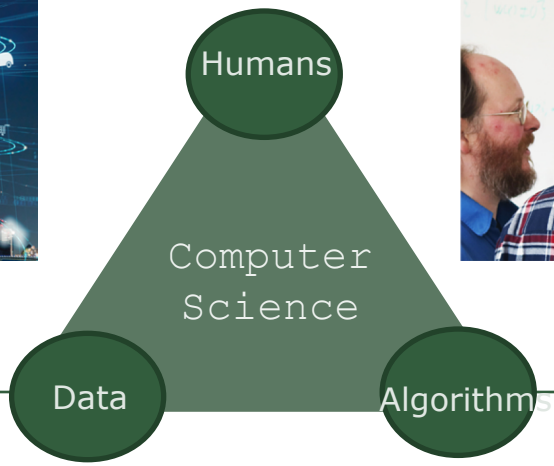
PETER NAUR DL

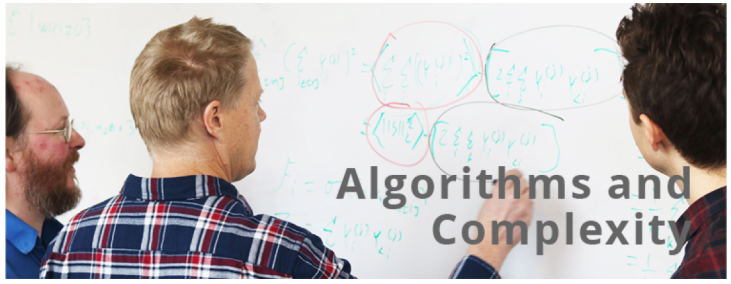
Denmark – 2005

CITATION

For fundamental contributions to programming language design and the definition of Algol 60, to compiler design, and to the art and practice of computer programming.

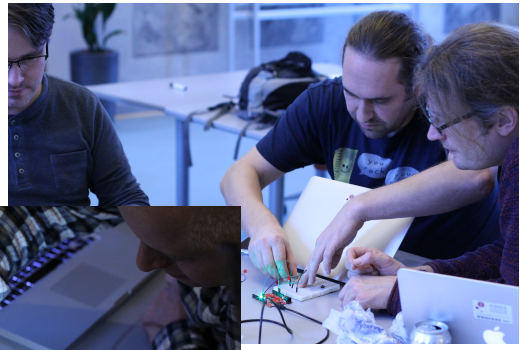
DIKU 6 Research Sections

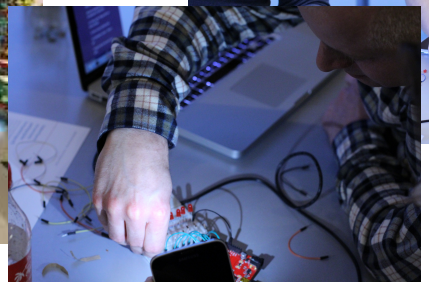




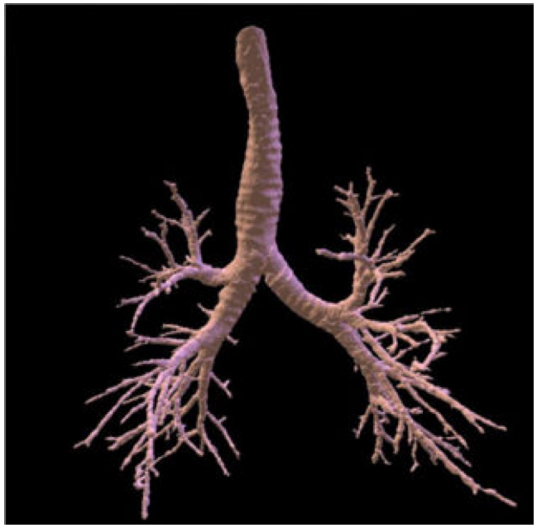
DIKU research laboratories

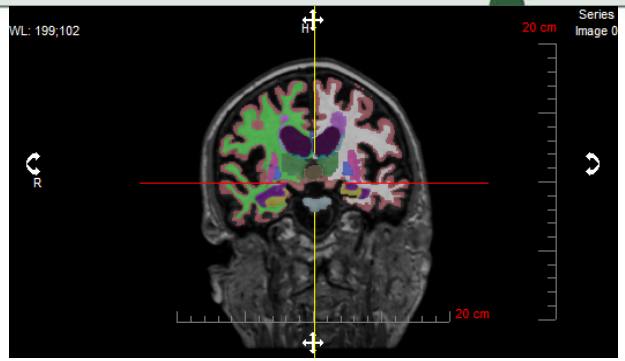
Robotics Lab
Personal Digital Fabrication (e.g. 3D printing)
Computational Resources
Virtual Reality/Augmented reality
Makerspace (e.g. Internet-of-Things)
Lego Lab

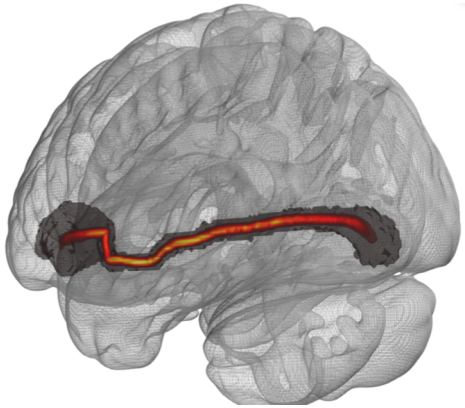


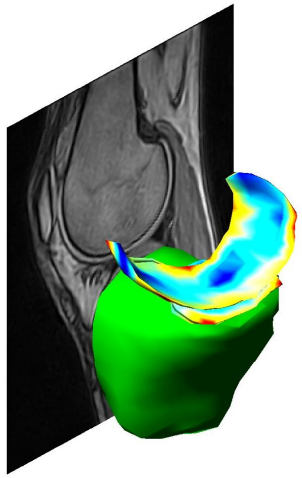


Complicated models for population and personalized health studies

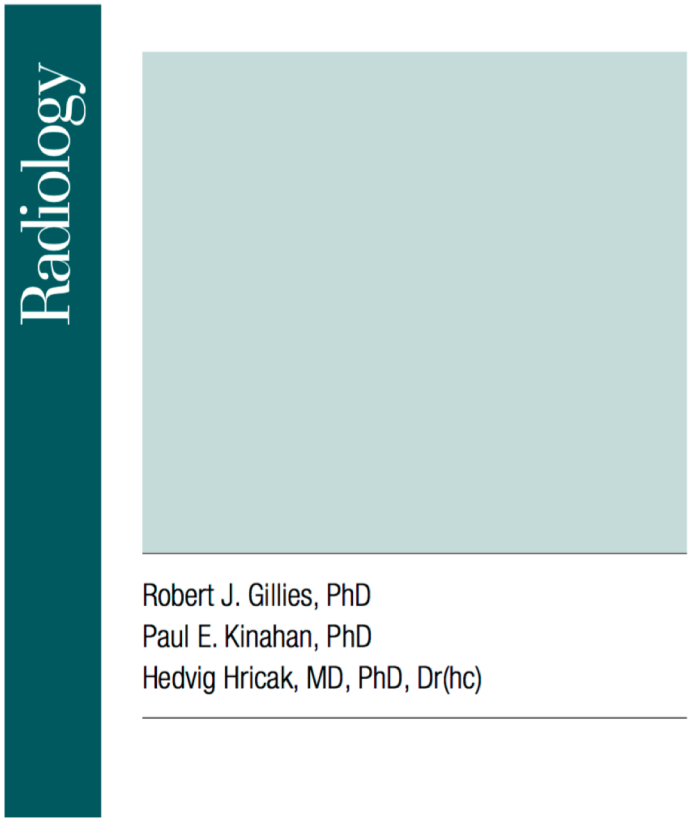








Radiomics



Robert J. Gillies, PhD
Paul E. Kinahan, PhD
Hedvig Hricak, MD, PhD, Dr(hc)

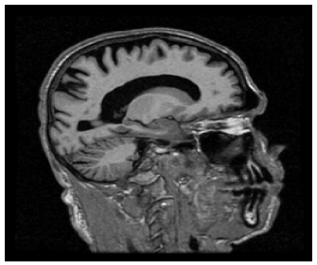
Radiomics: Images Are More than Pictures, They Are Data[1]

Radiomics: Extracting more information from medical images using advanced feature analysis

Philippe Lambin[e,f], Emmanuel Rios-Velazquez[e], Ralph Leijenaar[e], Sara Carvalho[e], Ruud G.P.M. Stiphout[e], Patrick Granton[e], Catharina M.L. Zegers[e], Robert Gillies[e], Ronald Boellard[e], André Dekker[e], Hugo J.W.L. Aerts[e]

[e] On behalf of the QuIC-ConCePT consortium. See Appendix A for consortium participants.
[f] Leader of the workpackage: "imaging the invasive phenotype" of the QuIC-ConCePT grant.

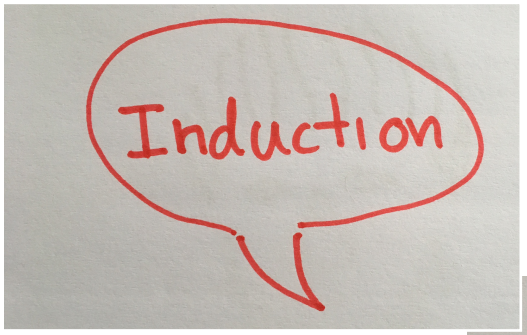
Radiomics

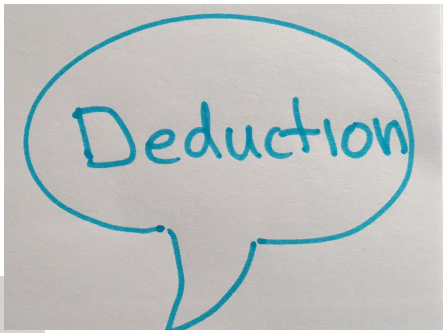


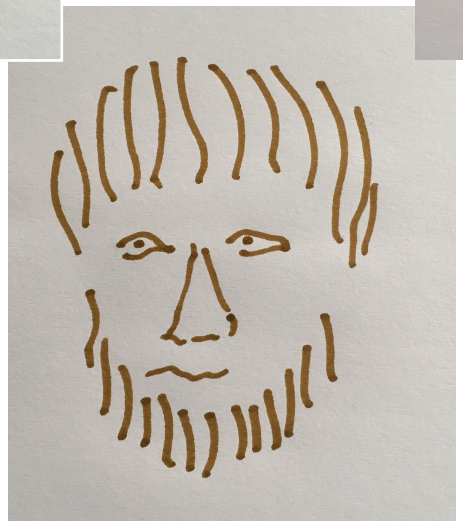
- Volumetry
- Edginess
- Blobbyness
- Histogram
- Lineliness

→ Machine Learning → Tumor profile

Reasoning

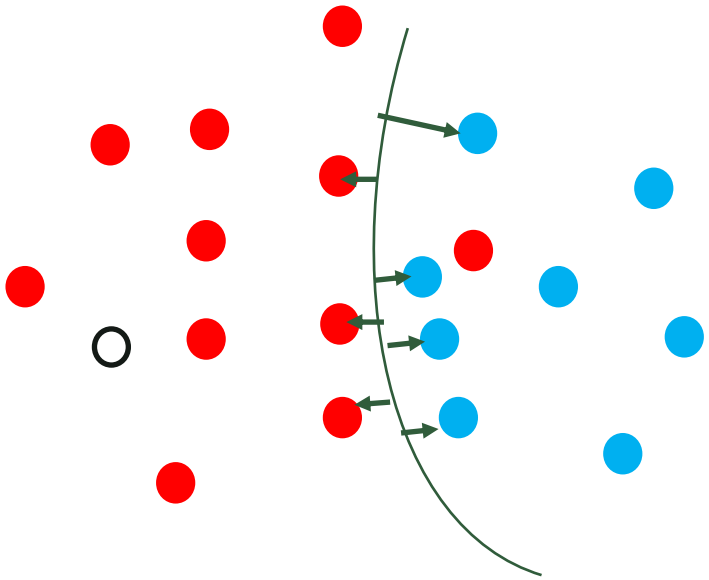






Aristoteles 384-322 BC

Inference from examples



Precise description of learning

Data x

Label y: $s_i = (x_i, y_i)$

$S = \{ s_1, s_2, \dots , s_N \};$

Machine learning:

$y = f(x, \Theta)$

Find Θ

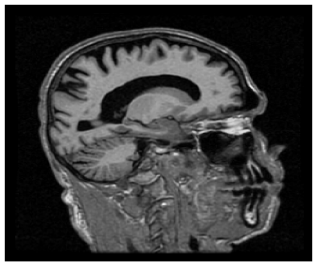
so f fits y

as well as possible

on new data

Generalisation

Radiomics



- Volumetry
- Edginess
- Blobbyness
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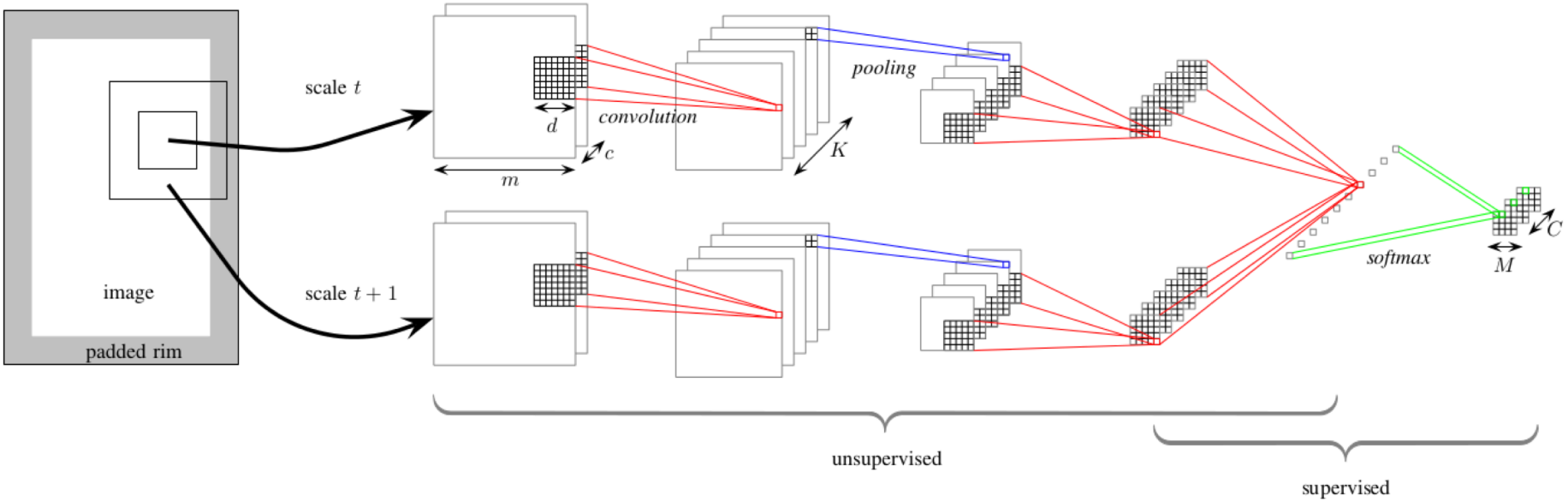
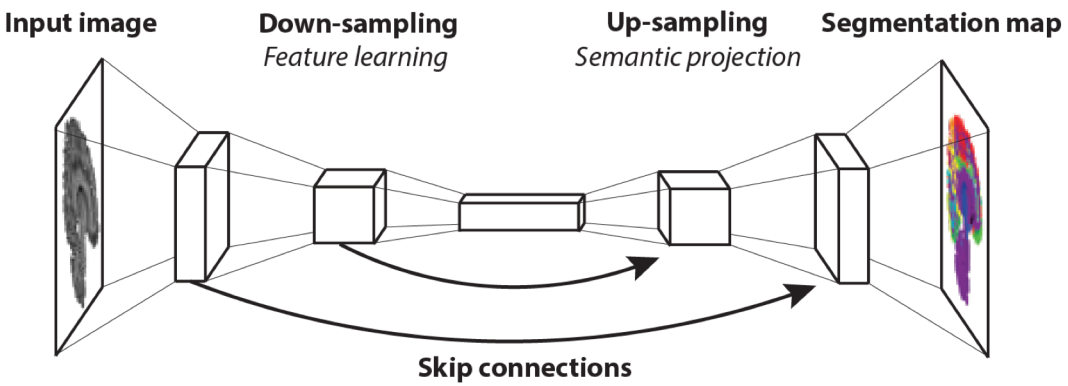
- Lineliness

→ Machine Learning → Tumor profile

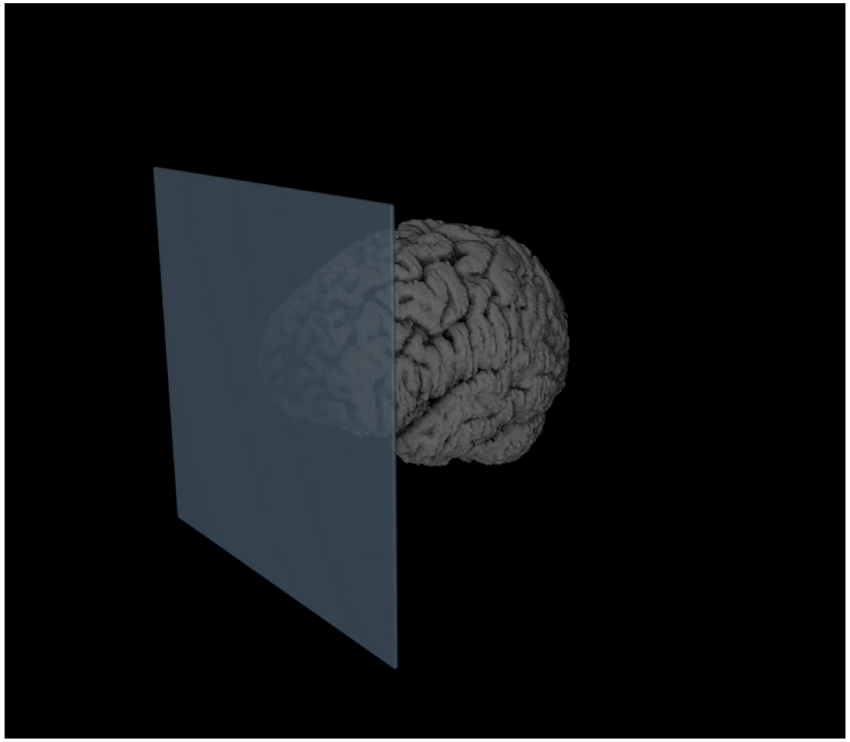
Deep learning and CNN

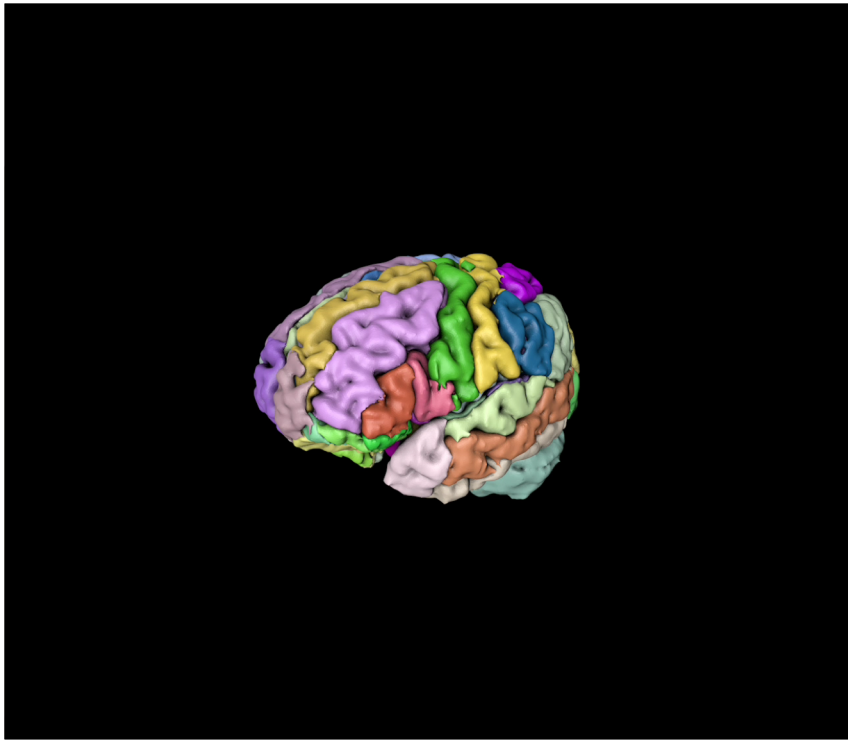


Segmentation: Fully Convolutional Neural Networks



Medical imaging



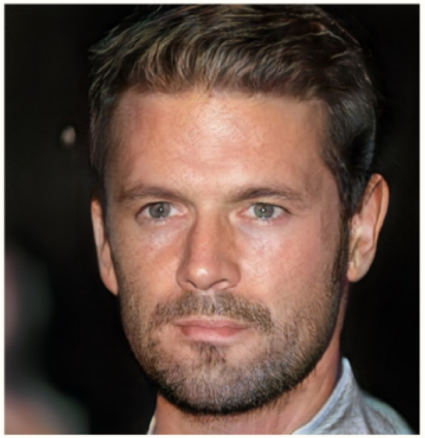


Extreme development

2014

2015

2016



2017

Karras et al., Progressive Growing of GANs for Improved Quality, Stability, and Variation, ICLR 2018

Impact

IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 35, NO. 5, MAY 2016 1153

Guest Editorial
Deep Learning in Medical Imaging: Overview and Future Promise of an Exciting New Technique

Deep Feature Learning for Knee Cartilage Segmentation Using a Triplanar Convolutional Neural Network*

Adhish Prasoon[1], Kersten Petersen[1], Christian Igel[1]**, François Lauze[1], Erik Dam[2], and Mads Nielsen[1,2]

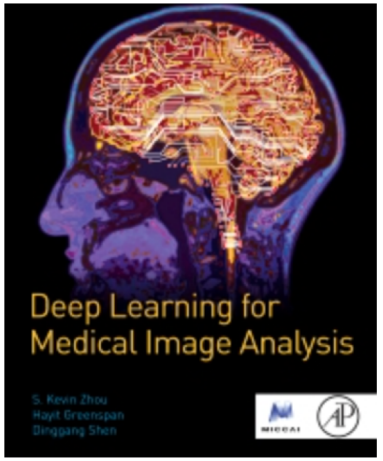
[1] Department of Computer Science, University of Copenhagen, Denmark
[2] Biomediq, Denmark

Breast Density Scoring with Multiscale Denoising Autoencoders

Kersten Petersen[1], Konstantin Chernoff[1], Mads Nielsen[1,2], and Andrew Y. Ng[3]

[1] Department of Computer Science, University of Copenhagen, Denmark
[2] Biomediq A/S, Denmark
[3] Department of Computer Science, Stanford University, United States

2012 2013 2016 2017 2018



International conference on

Medical Imaging with Deep Learning

Amsterdam, 4 – 6th July 2018

info@midl.amsterdam

AI in healthcare

Resource management

- workflow optimization

Diagnosis/treatment planning support

- quantification and disease modelling
- personalized medicine

Automated diagnosis/treatment planning

- Big data and quantification
- Personalized medicine

Automated treatment

- Robotics

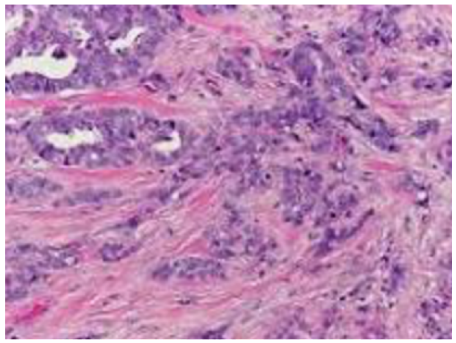
Ressource management

Forecasting of resources

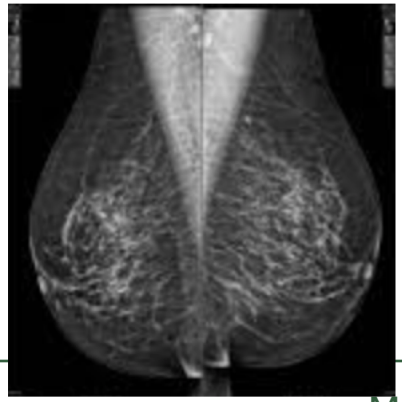
- Patients on need of XX, YY
- Stock of resources of limited durability

Forecasting of risk

- Pathology



- Screening



Diagnostics

Diagnostic workflow

- time efficiency
- scanner efficiency
- triage
- reading help
  - similar case finder
  - augmentation

Contents lists available at ScienceDirect

Medical Image Analysis

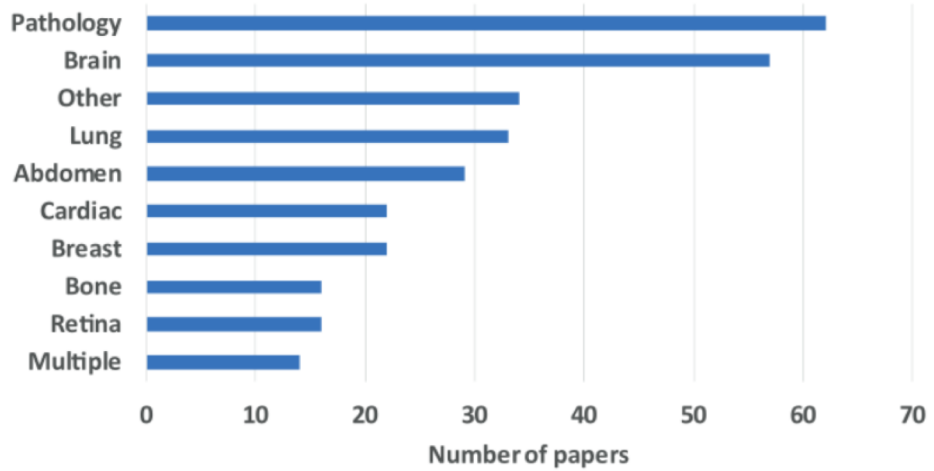
journal homepage: www.elsevier.com/locate/media

Survey Paper

A survey on deep learning in medical image analysis

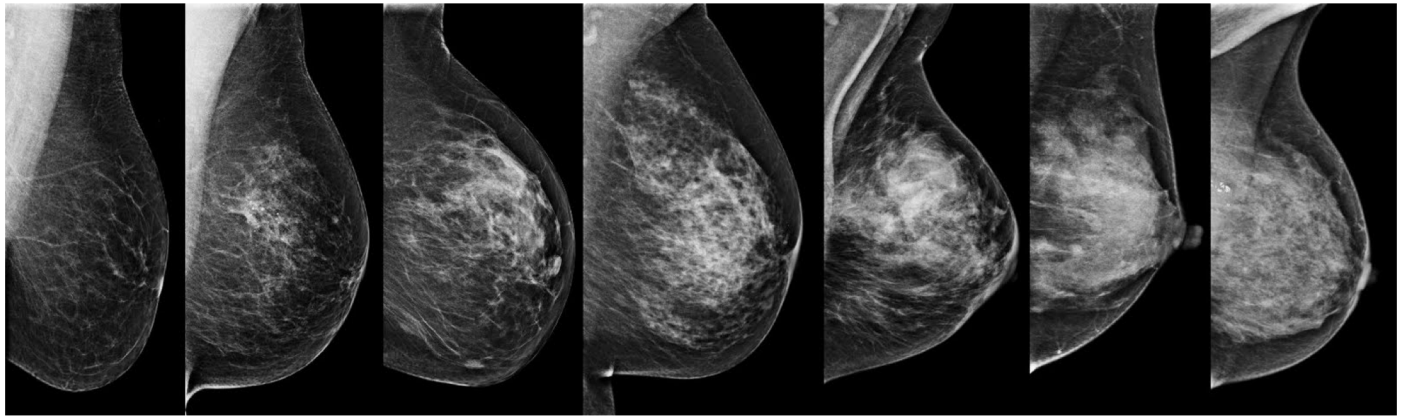
Geert Litjens*, Thijs Kooi, Babak Ehteshami Bejnordi, Arnaud Arindra Adiyoso Setio, Francesco Ciompi, Mohsen Ghafoorian, Jeroen A.W.M. van der Laak, Bram van Ginneken, Clara I. Sánchez

Diagnostic Image Analysis Group, Radboud University Medical Center, Nijmegen, The Netherlands



Breast Cancer Screening

Mammographic Breast Density

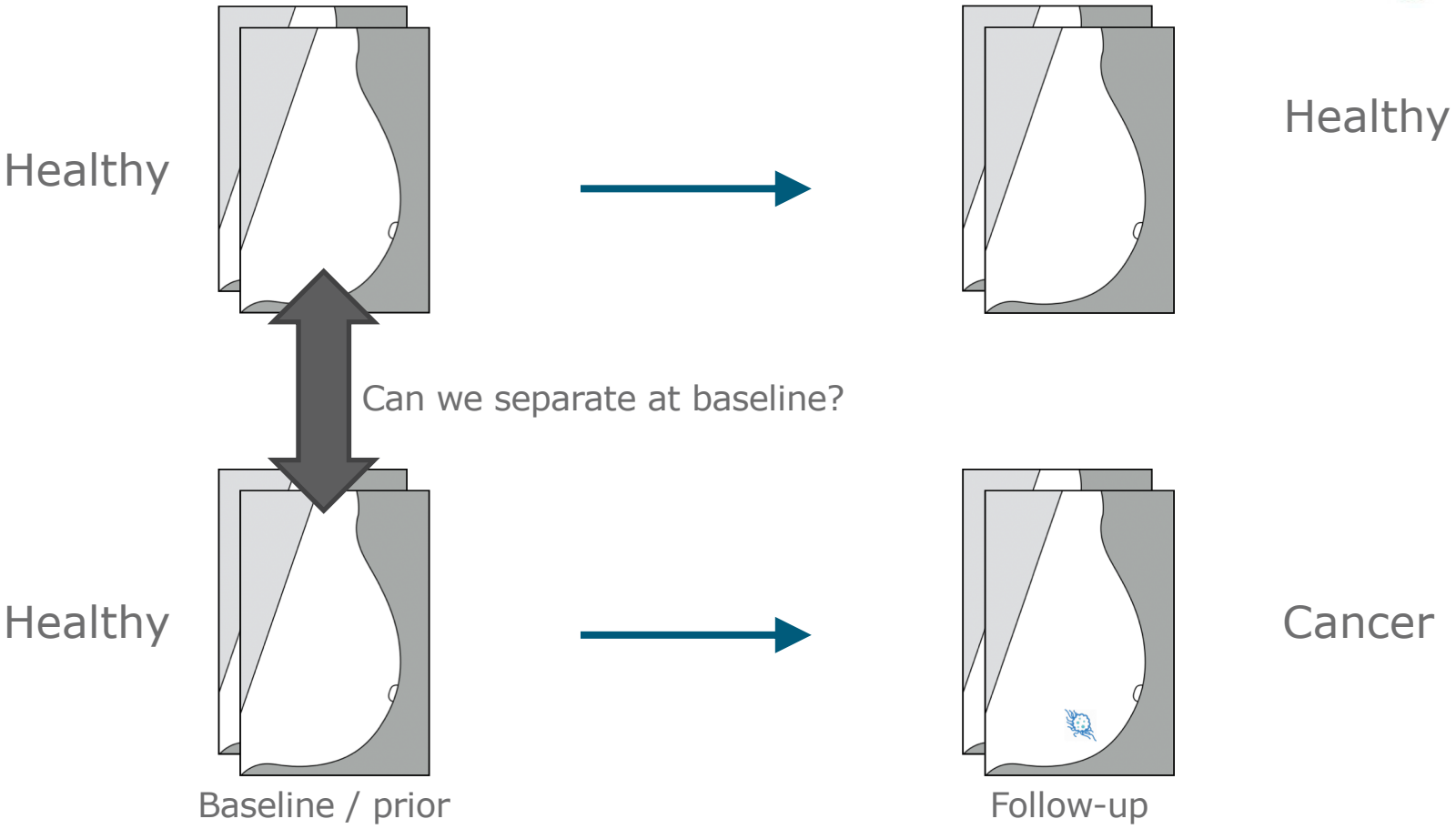


Breast cancer risk [1,2]

Masking risk [3]

[1] V. A. Mc Cormack et al., Cancer Epidemiol Biomarkers Prev, 15-6, 1159-69, 2006
[2] C. M. Vachon et al., Breast Cancer Res, 9-6, 217, 2007
[3] P.A. Carney et al., Ann Intern Med, 138, 168-175, 2003

Training design – mammographic cancer risk



BMC Cancer

December 2016, 16:414 | Cite as

Mammographic density and structural features can individually and jointly contribute to breast cancer risk assessment in mammography screening: a case–control study

Authors | Authors and affiliations

Rikke Rass Winkel, My von Euler-Chelpin, Mads Nielsen, Kersten Petersen, Martin Lillholm, Michael Bachmann Nielsen, Elsebeth Lynge, Wei Yao Uldall, Ilse Vejborg

Unsupervised Deep Learning Applied to Breast Density Segmentation and Mammographic Risk Scoring

Michiel Kallenberg*, Kersten Petersen, Mads Nielsen, Andrew Y. Ng, Pengfei Diao, Christian Igel, Celine M. Vachon, Katharina Holland, Rikke Rass Winkel, Nico Karssemeijer, and Martin Lillholm

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Breast Cancer Research

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Research article | Open Access

The combined effect of mammographic texture and density on breast cancer risk: a cohort study

Johanna O. P. Wanders, Carla H. van Gils, Nico Karssemeijer, Katharina Holland, Michiel Kallenberg, Petra H. M. Peeters, Mads Nielsen and Martin Lillholm

Breast Cancer Research 2018 **20**:36

https://doi.org/10.1186/s13058-018-0961-7

Received: 16 July 2017 | **Accepted:** 21 March 2018 | **Published:** 2 May 2018

Breast Cancer Research and Treatment

October 2018, Volume 171, Issue 3, pp 767–776 | Cite as

Screening mammography: benefit of double reading by breast density

Authors | Authors and affiliations

My von Euler-Chelpin, Martin Lillholm, George Napolitano, Ilse Vejborg, Mads Nielsen, Elsebeth Lynge

ELSEVIER

Cancer Epidemiology

Volume 49, August 2017, Pages 53-60

Risk stratification of women with false-positive test results in mammography screening based on mammographic morphology and density: A case control study

Rikke Rass Winkel, My von Euler-Chelpin, Elsebeth Lynge, Pengfei Diao, Martin Lillholm, Michiel Kallenberg, Julie Lyng Forman, Michael Bachmann Nielsen, Wei Yao Uldall, Mads Nielsen, Ilse Vejborg

UICC global cancer control

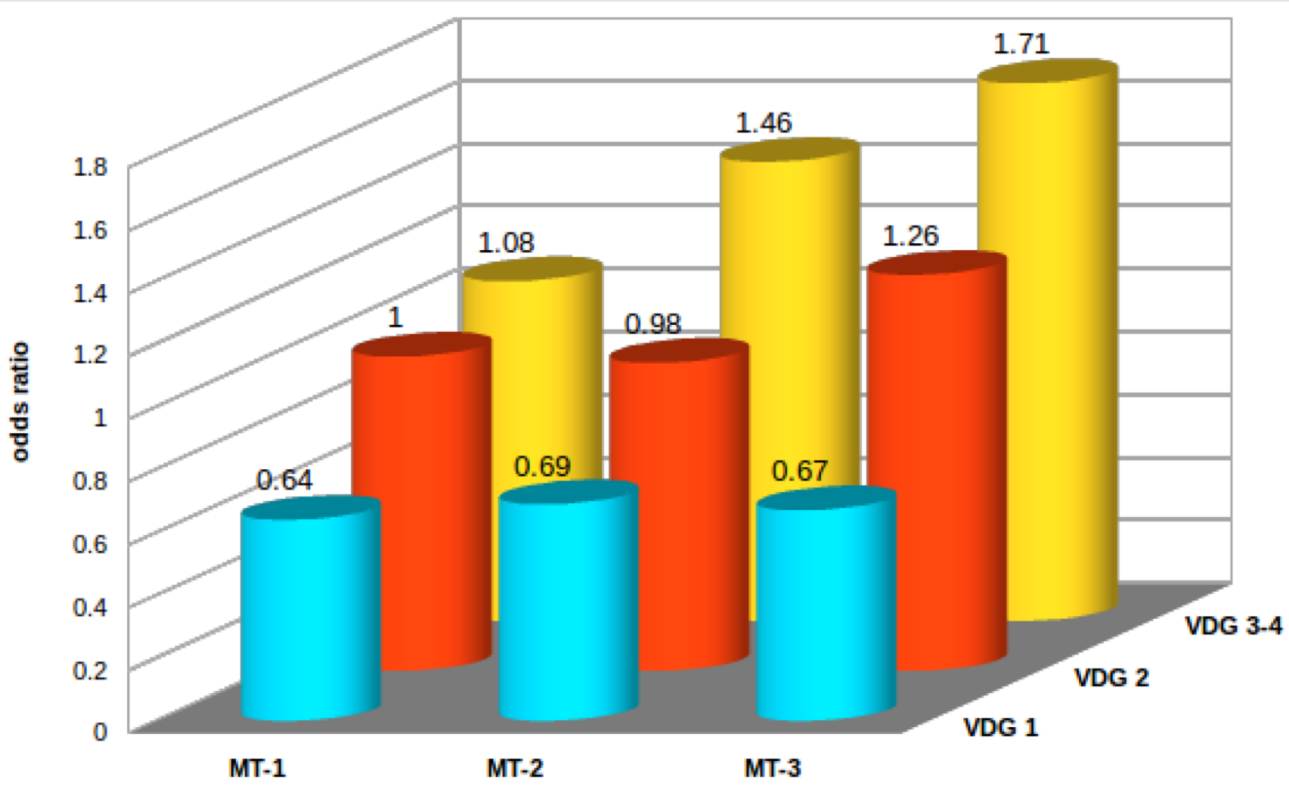
IJC International Journal of Cancer

Change in mammographic density across birth cohorts of Dutch breast cancer screening participants

George Napolitano[1], Elsebeth Lynge[2], Martin Lillholm[3], Ilse Vejborg[4], Carla H. van Gils[5], Mads Nielsen[3] and Nico Karssemeijer[6]

[1]Department of Public Health, University of Copenhagen, Copenhagen, Denmark
[2]Nykøbing Falster Hospital, University of Copenhagen, Copenhagen, Denmark
[3]Department of Computer Sciences, University of Copenhagen, Copenhagen, Denmark
[4]Department of Radiology, University Hospital Copenhagen, Copenhagen, Denmark
[5]Department of Epidemiology, Julius Center for Health, Sciences and Primary Care, University Medical Center Utrecht, Utrecht University, Utrecht, The Netherlands
[6]Department of Radiology and Nuclear Medicine, Radboud University, Medical Center, Nijmegen, The Netherlands

INTERACTION WITH DENSITY



Odds ratios for different combinations of texture-density
54808 mammograms from November 1 2012 to December 31 2013, Capital Region of Denmark

SCREENING INTERVAL

	MT-1	MT-2	MT-3
VD-1	38	35	36
VD-2	24	24	19
VD-3/4	22	16	14

COST AND BENIFIT

Benifit: We detect cancers with screening interval on average 16% (2 months) shorter

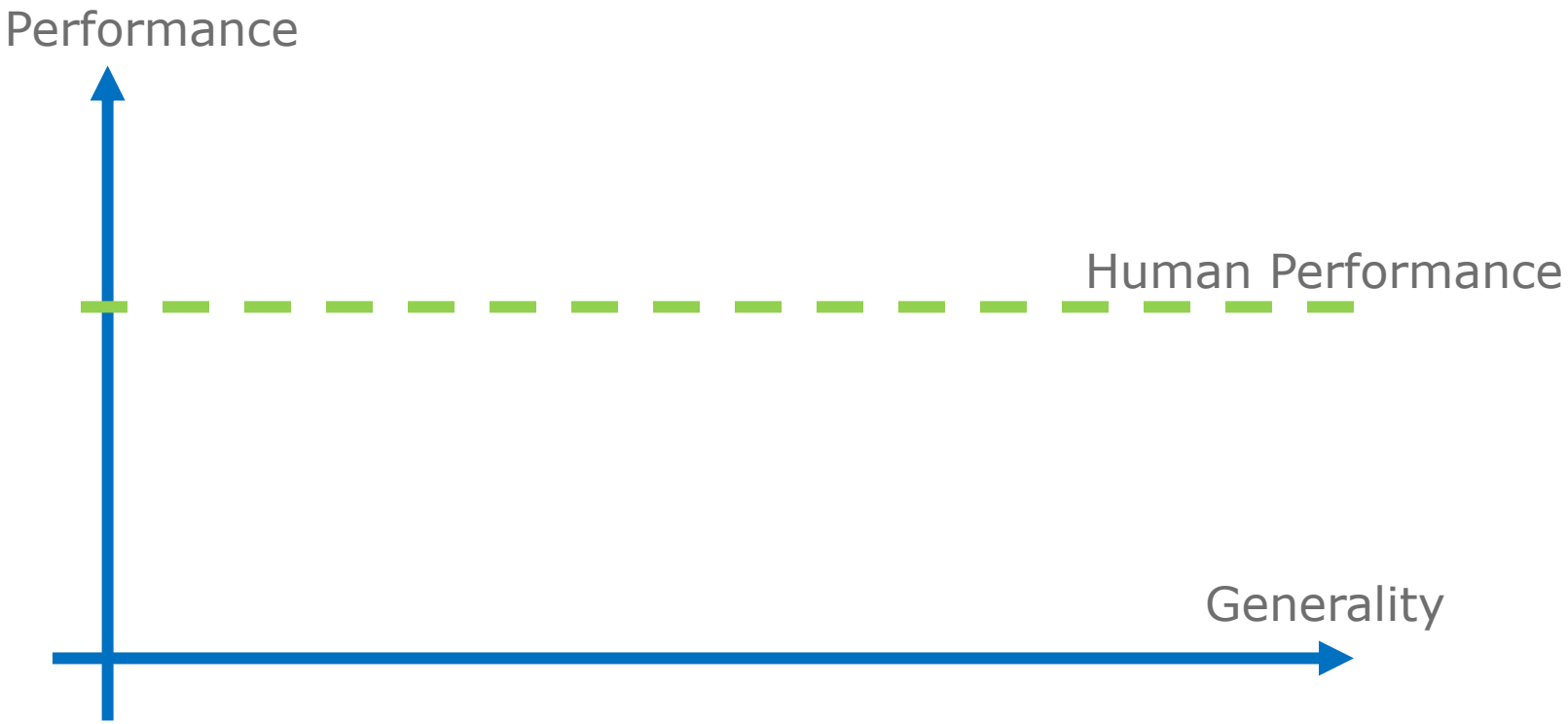
Cost: 30% of women (19% of cancers) have a longer screening interval (>24 months)

Should we treat the women or the cancers equal?

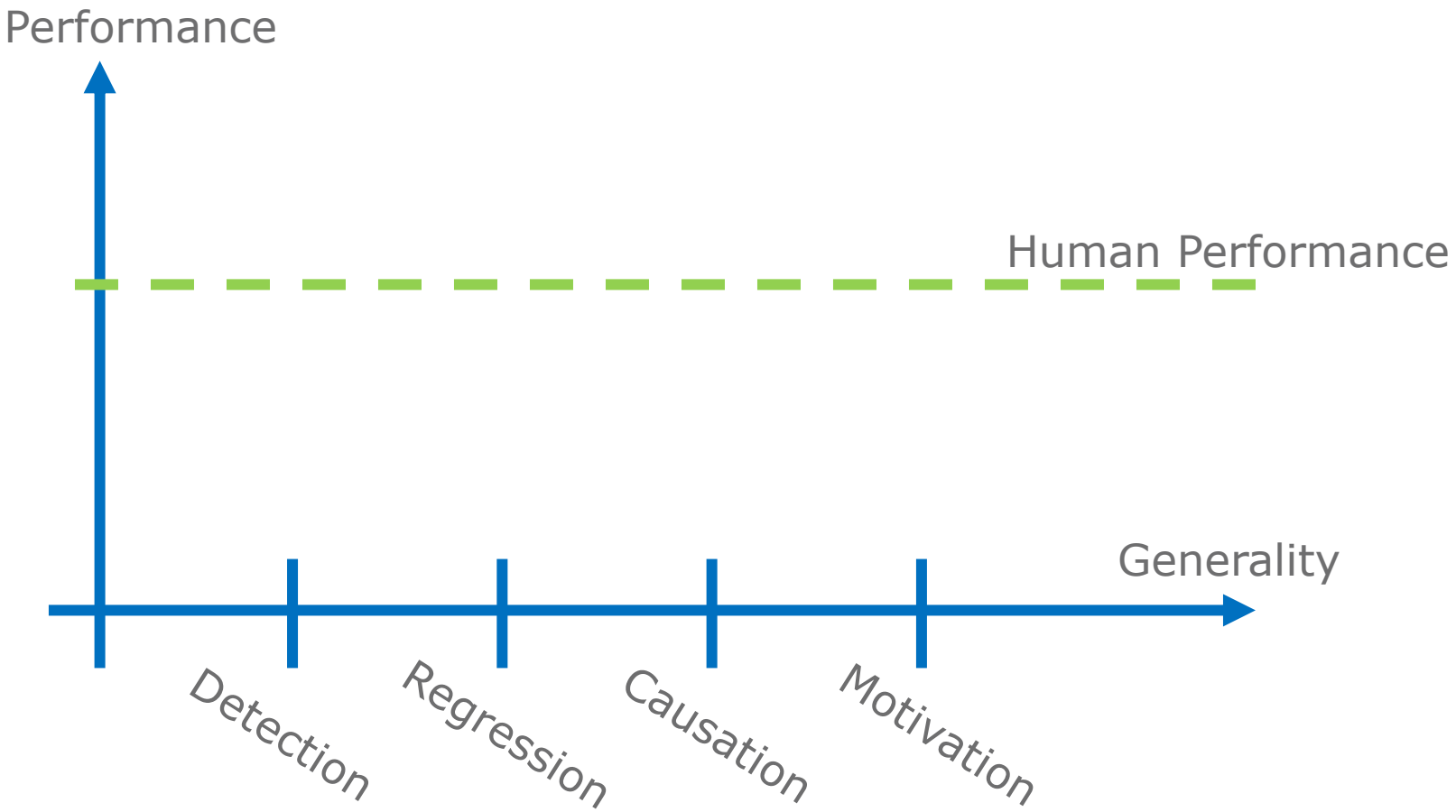
AI properties

AI Performance

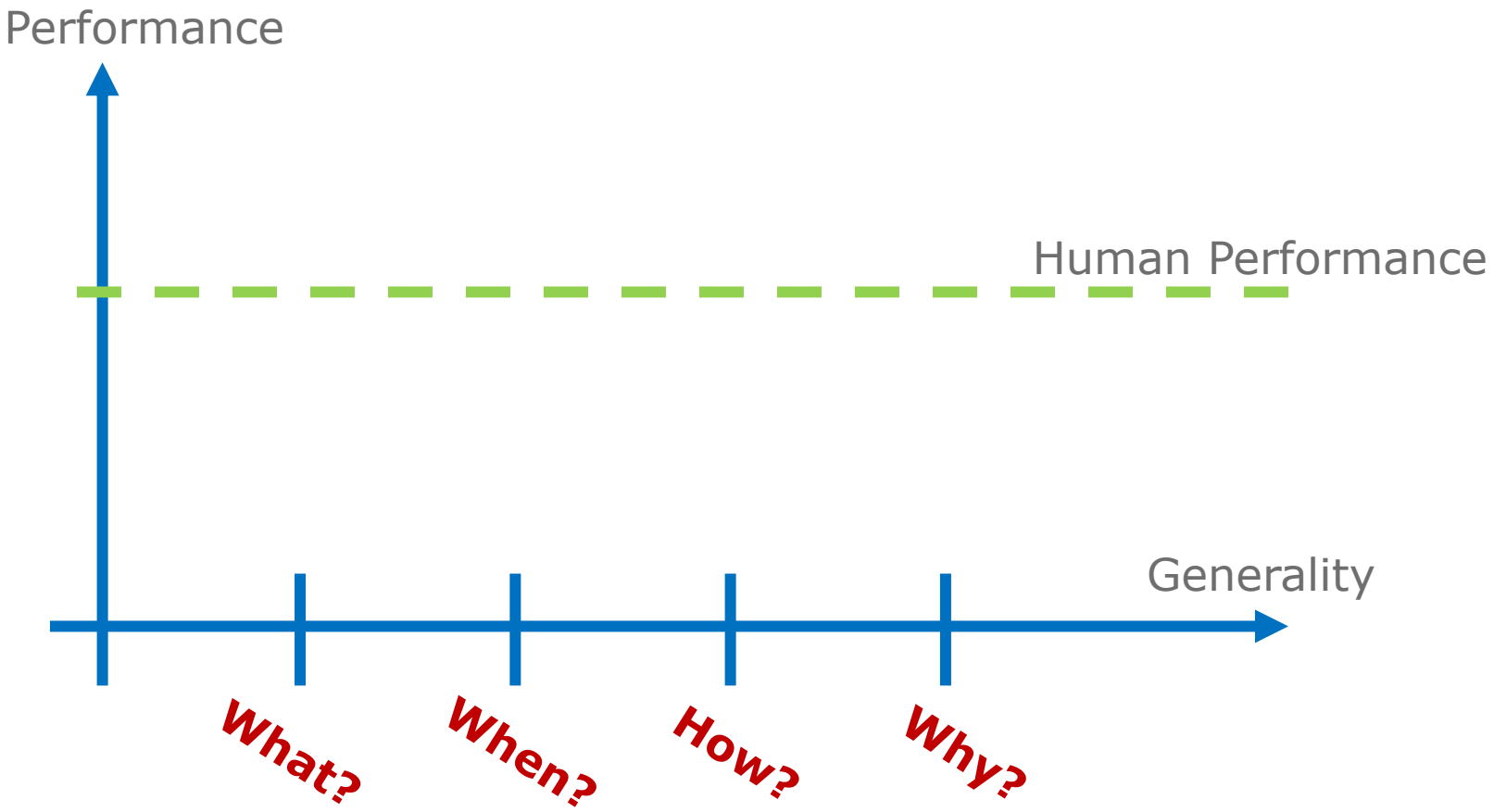
AI Performance



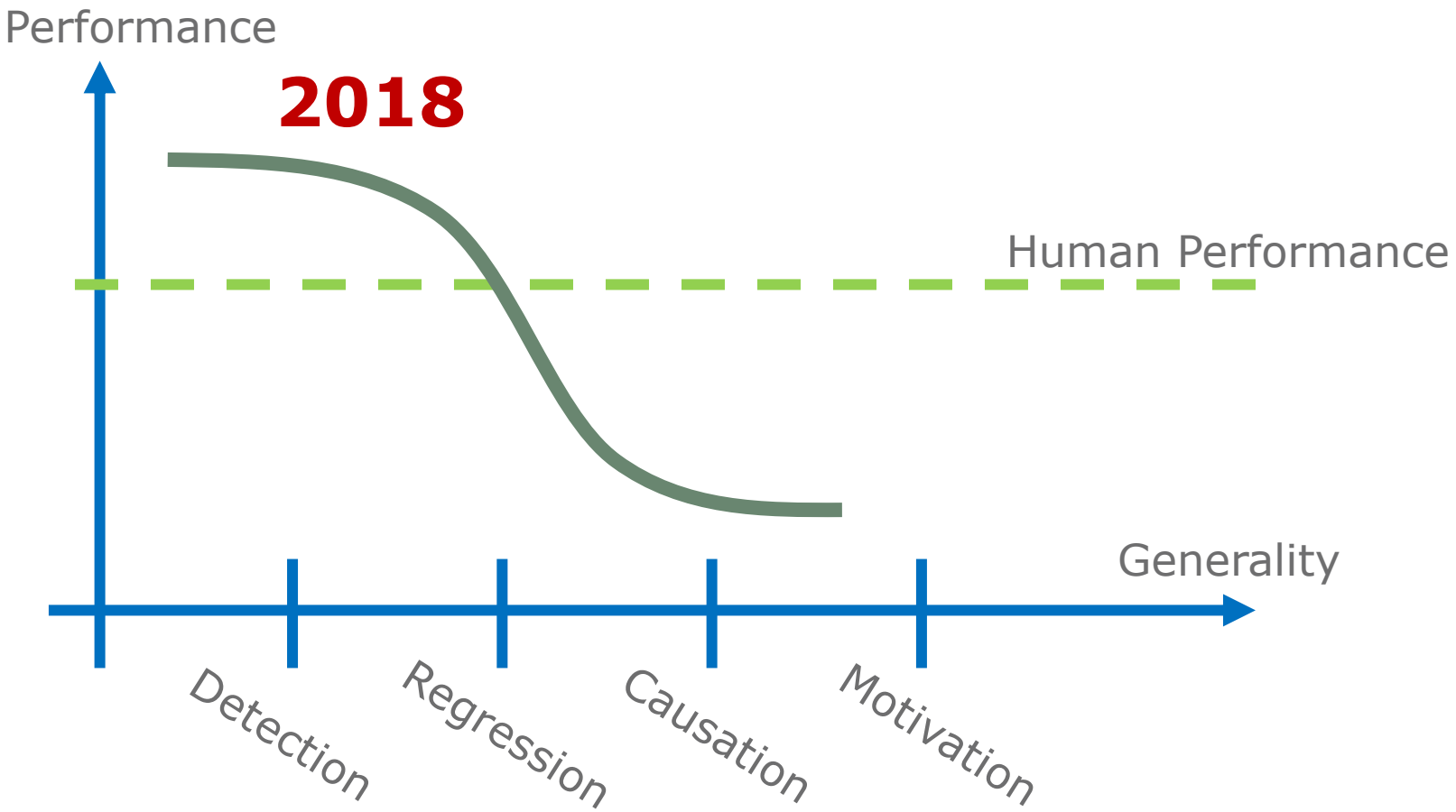
AI Performance



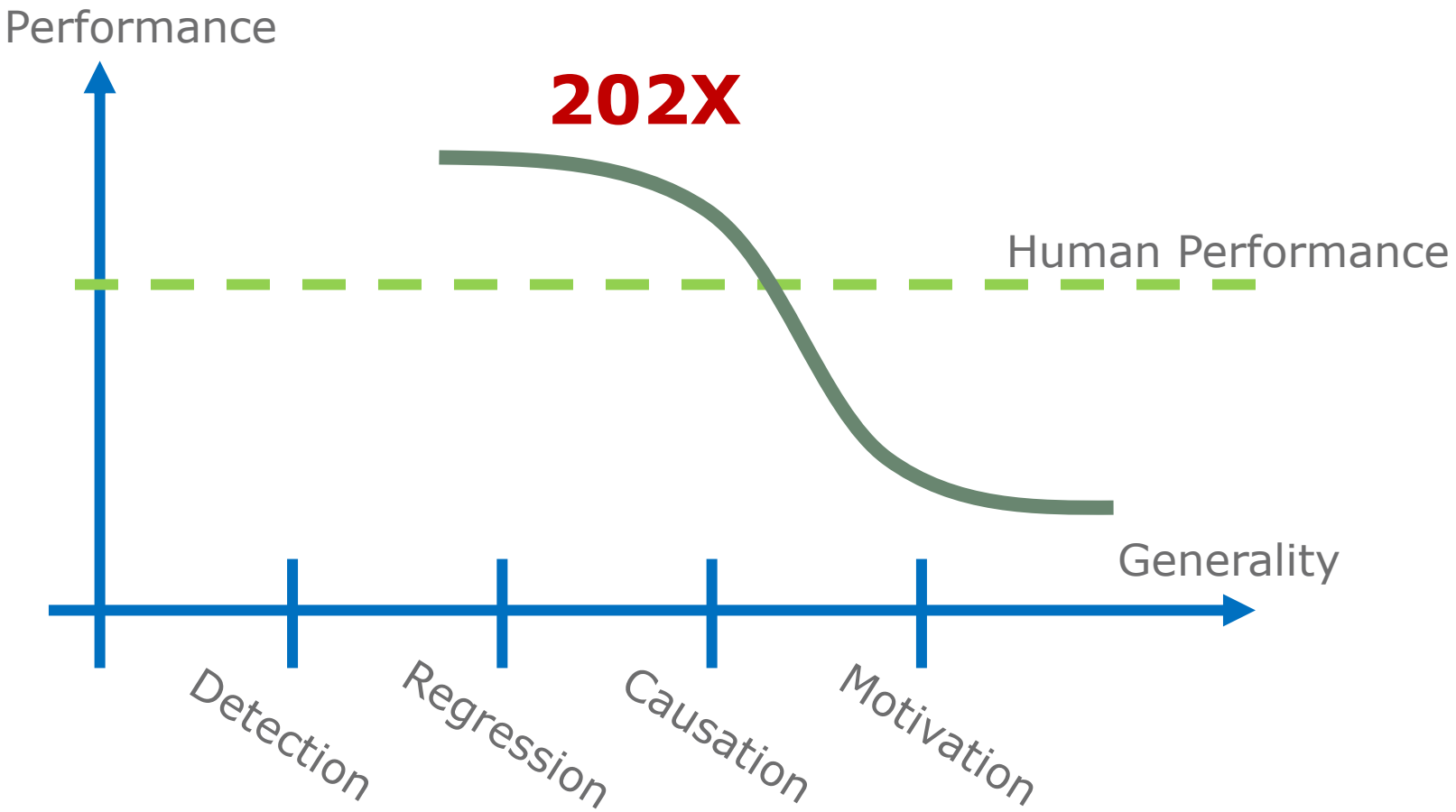
AI Performance



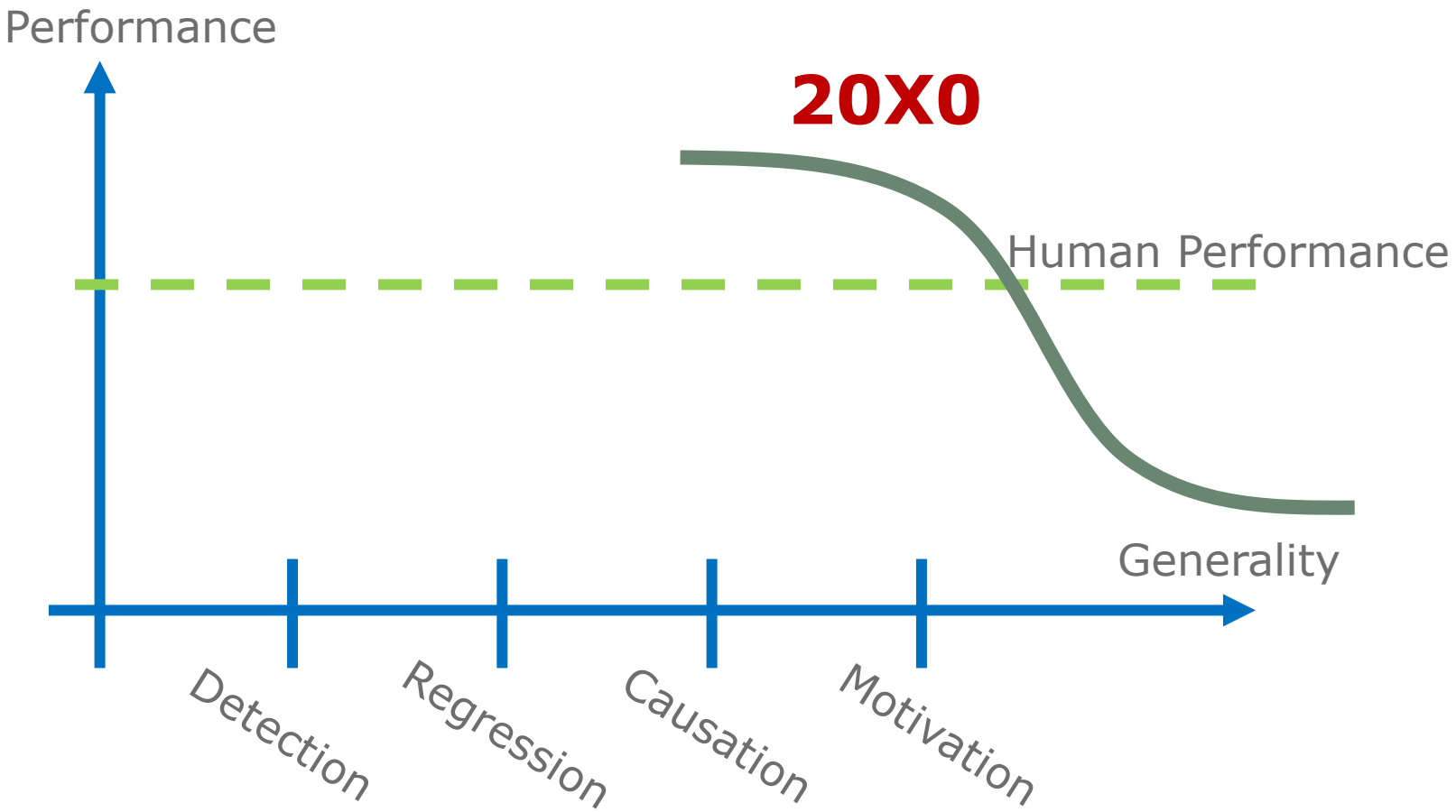
AI Performance

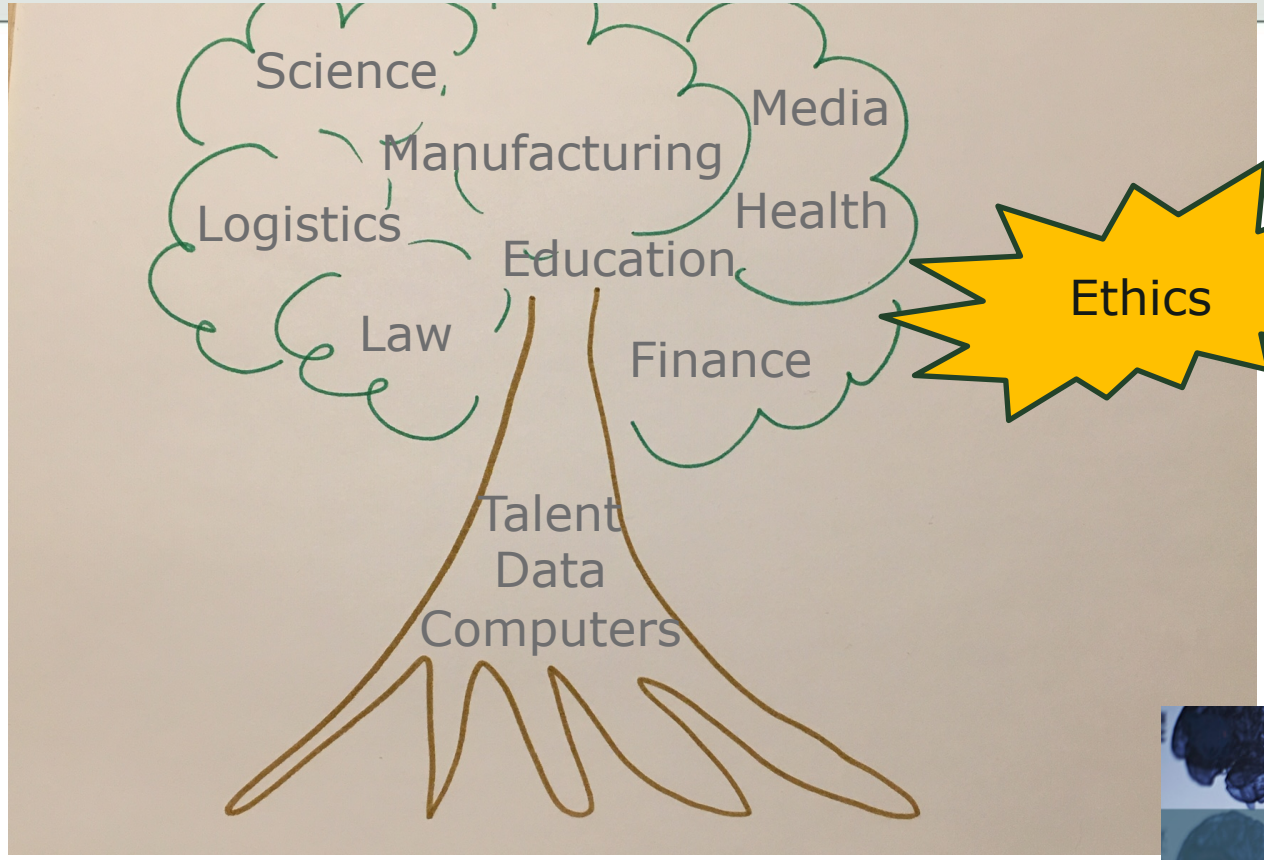


AI Performance



AI Performance

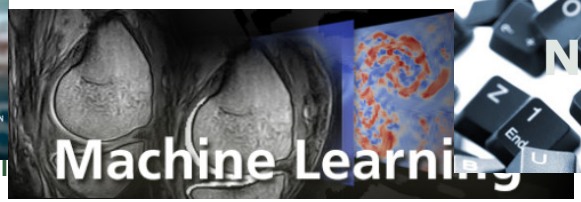




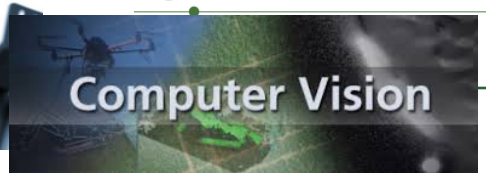
DATA SCIENCE LAB

BASIC ALGORITHM RESEARCH COPENHAGEN

BARC



Electronic Research Data Archive
University of Copenhagen



Deep Learni