AI in Medical Imaging

DSMMR Årsmøde
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How many of you use AI clinically?

What is AI?

> "All the impressive achievements of deep learning amount to just curve fitting"
>
> –Judea Pearl

What is AI?

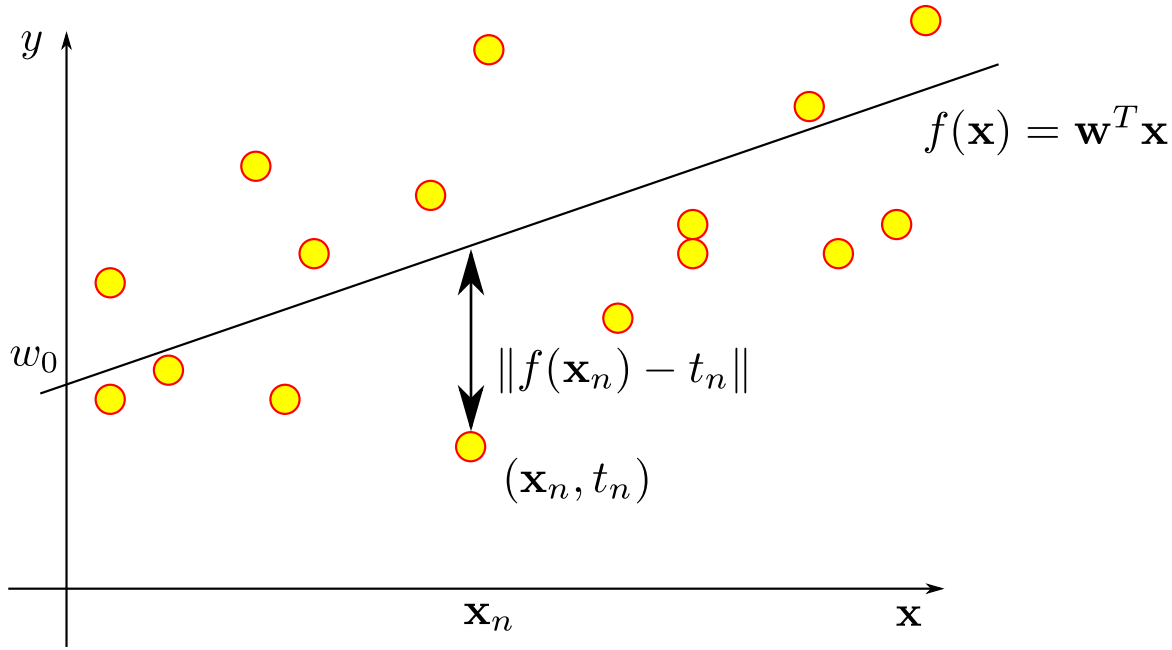
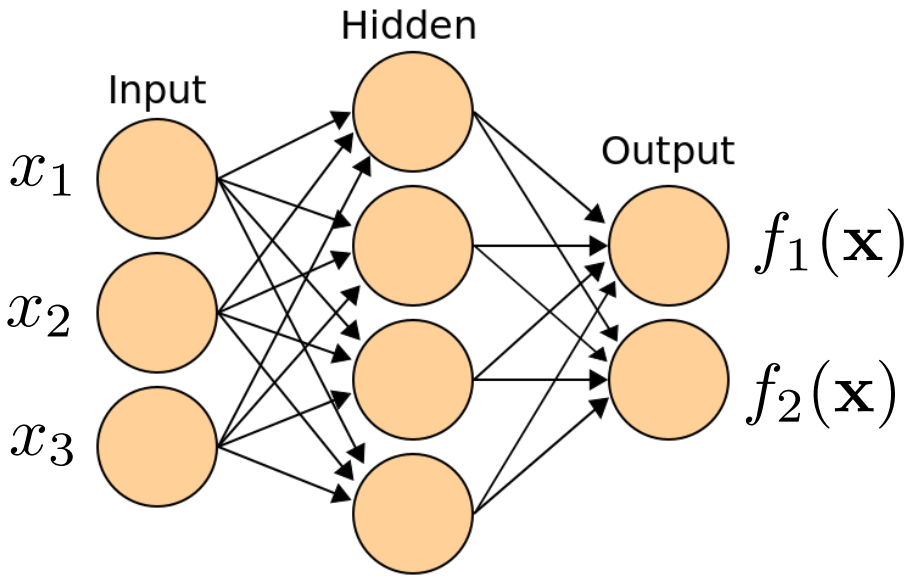


Figure: Linear regression = line fitting

What is AI?

Whatever your problem, the key is to phrase it as 'curve" fitting.



$$\mathbf{x} = (x_1, x_2, x_3)$$

Optimize loss:

$$L(\mathbf{y}, f(\mathbf{x}))$$

Figure: Neural network training = function fitting

AI in medical imaging: Diagnosis/Risk scoring/anomaly detection/decision support

Deep Multi-modal Latent Representation Learning for Automated Dementia Diagnosis

Tao Zhou[1], Mingxia Liu[2(✉)], Huazhu Fu[1], Ling Shao[1], and Dingga

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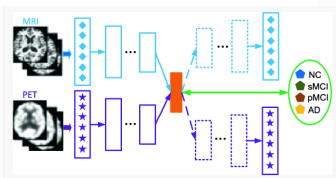


International Conference on Medical Image Computing and Computer-Assisted Intervention

MICCAI 2019: Medical Image Computing and Computer Assisted Intervention – MICCAI 2019 pp 205-213 | Cite as

Early Prediction of Alzheimer's Disease Progression Using Variational Autoencoders

Authors | Authors and affiliations

Sumana Basu ✉, Konrad Wagstyl, Azar Zandifar, Louis Collins, Adriana Romero, Doina Precup

Conference paper

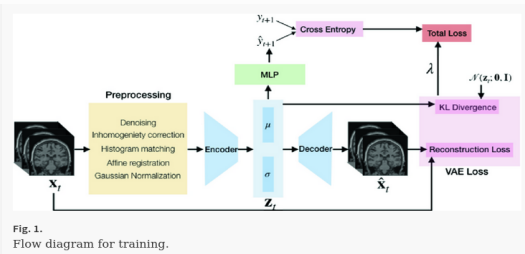


Fig. 1.
Flow diagram for training.

International Conference on Medical Image Computing and Computer-Assisted Intervention

MICCAI 2019: Medical Image Computing and Computer Assisted Intervention – MICCAI 2019 pp 289-297 | Cite as

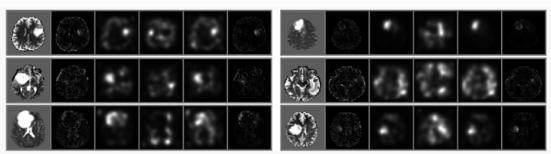
Unsupervised Anomaly Localization Using Variational Auto-Encoders

Authors

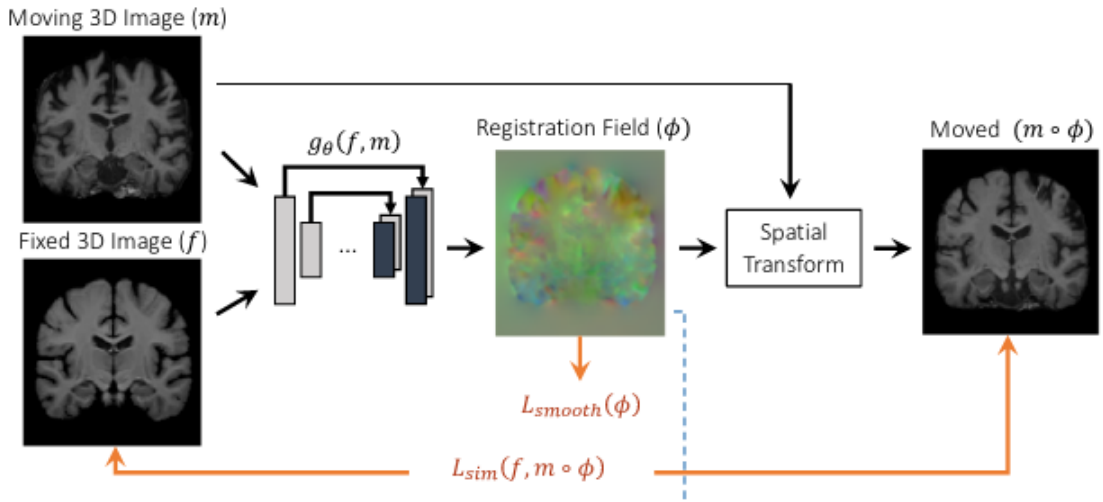
David Zimmerer ✉, Fabia

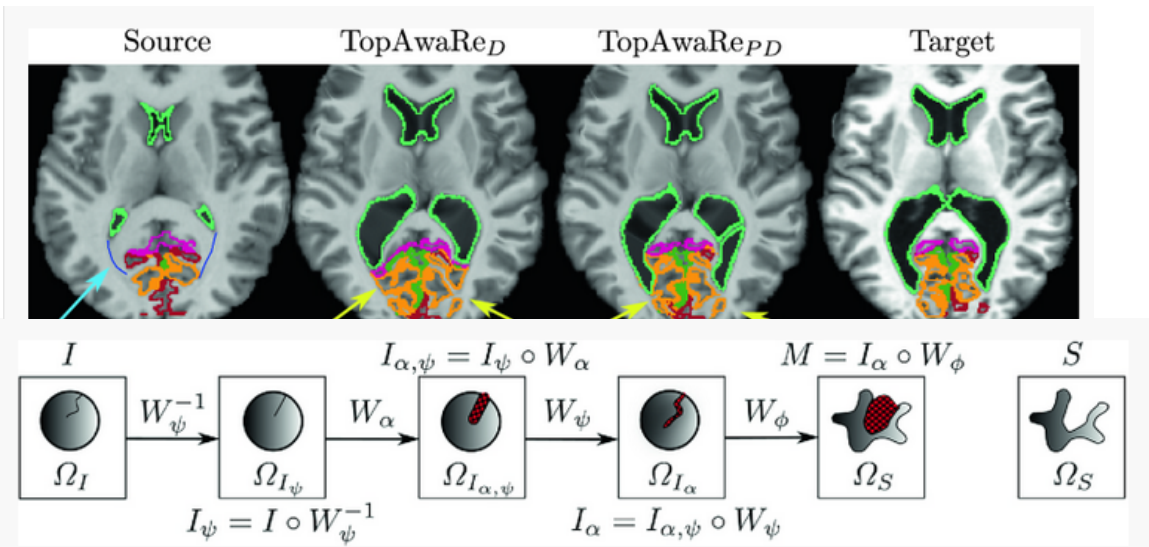
Conference paper

First Online: 10 October 2



AI in medical imaging: Image processing – Registration





AI in medical imaging: Image processing – Segmentation

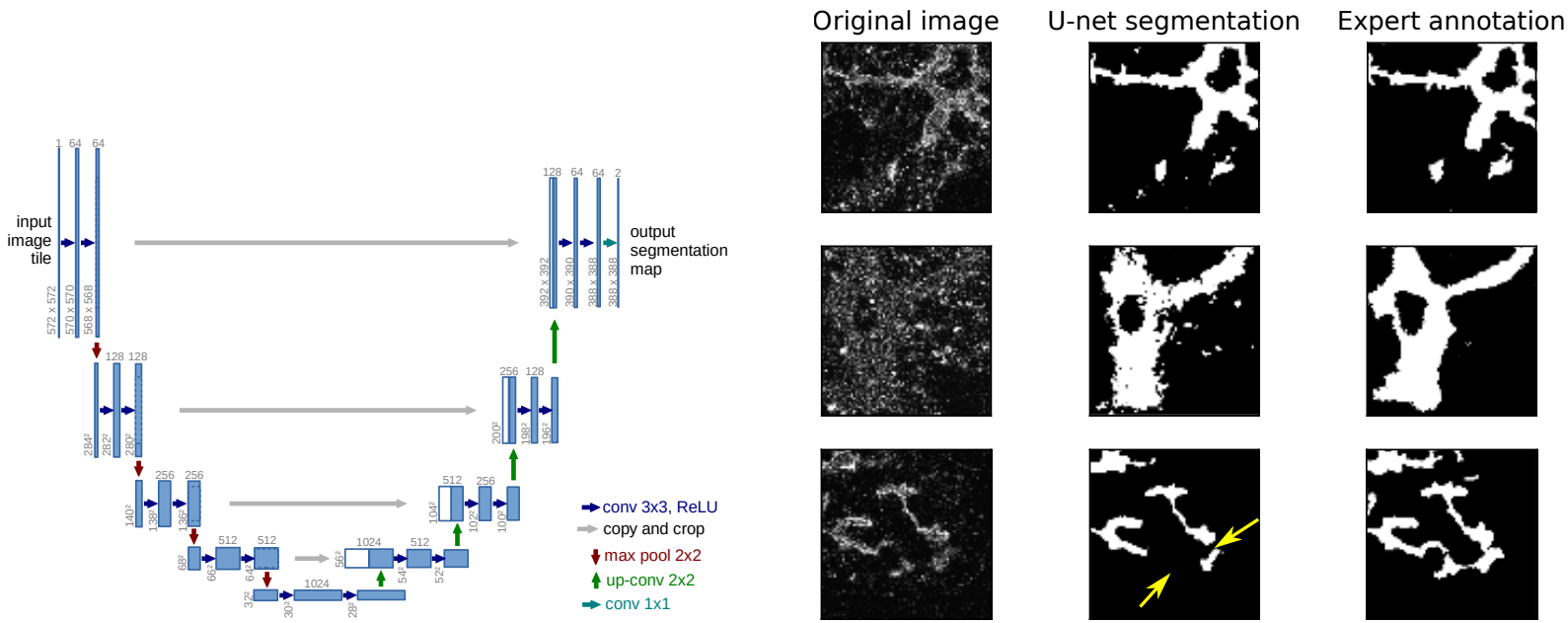


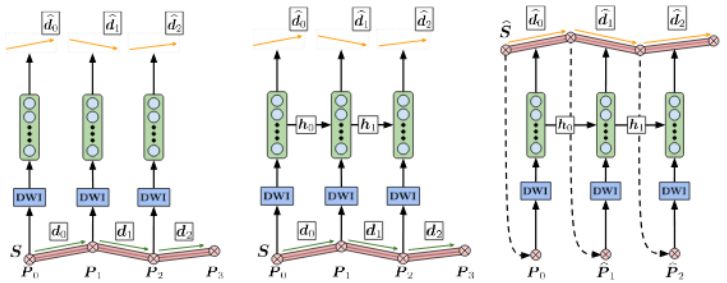
Figure: Left: Ronneberger et al, 2015. Right: Arnavaz et al, 2020

AI in medical imaging: Image processing – Tractography, microstructural properties

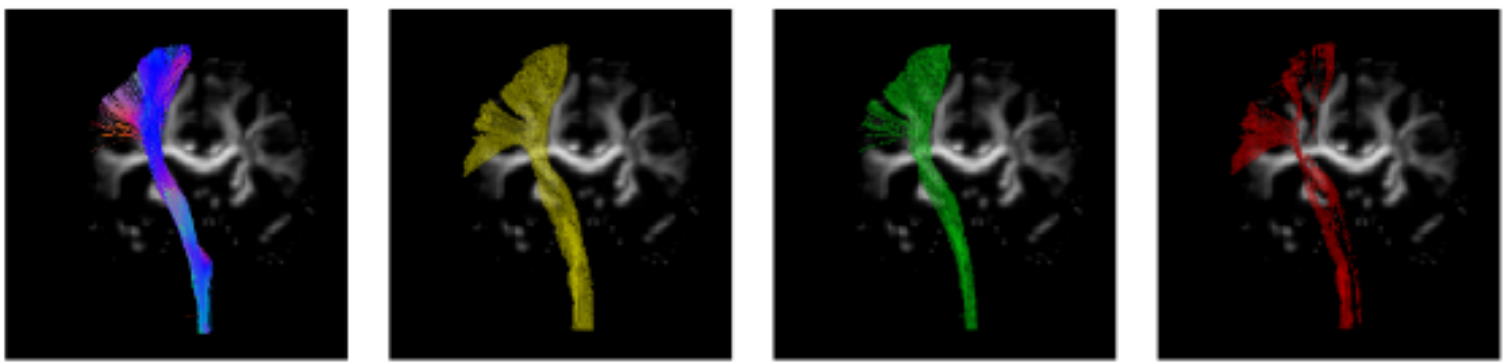
Learn to Track: Deep Learning for Tractography

Philippe Poulin[1], Marc-Alexandre Côté[2], Jean-Christophe Houde[2], Laurent Petit[4], Peter F. Neher[3], Klaus H. Maier-Hein[3], Hugo Larochelle[1], and Maxime Descoteaux[2]

[1] Computer Science Department, Université de Sherbrooke, Sherbrooke, Canada
[2] Sherbrooke Connectivity Imaging Laboratory (SCIL), Computer Science Department, Université de Sherbrooke, Sherbrooke, Canada
[3] Medical Image Computing (MIC), German Cancer Research Center (DKFZ), Heidelberg, Germany
[4] Groupe d'Imagerie Neurofonctionelle, IMN, CNRS, CEA, Université de Bordeaux, France



(a) FFNN training (b) RNN training (c) RNN tracking



(a) predicted (b) ground truth (c) overlap (d) overreach

AI in medical imaging: Image synthesis – CT from MR

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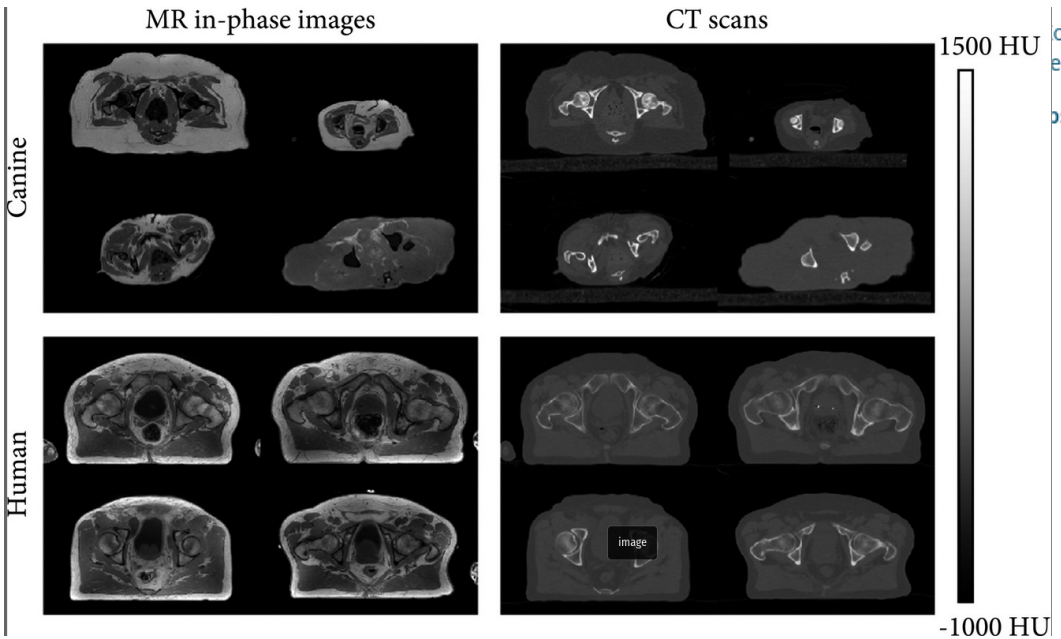
FULL PAPER | Open Access

Deep learning–based MR-to-CT synthesis: The influence of varying gradient echo–based MR images as input channels

oen Willemsen, Matteo Maspero, Cornelis A. T. van den Berg,
ein, Harrie Weinans, Max A. Viergever ... See all authors

os://doi.org/10.1002/mrm.28008 | Citations: 2



AI in medical imaging: Image processing: Denoising; high quality from low quality; movement removal

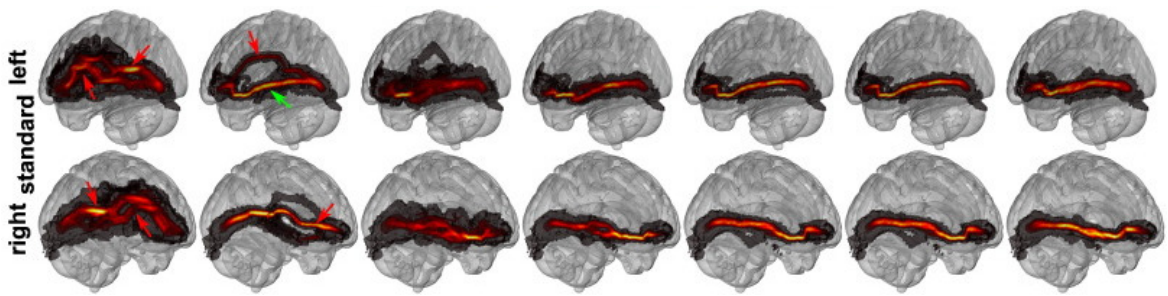
ELSEVIER

NeuroImage

Volume 130, 15 April 2016, Pages 63-76

Training shortest-path tractography: Automatic learning of spatial priors

Niklas Kasenburg [a], Matthew Liptrot [a, b], Nina Linde Reislev [c], Silas N. Ørting [a], Mads Nielsen [a], Ellen Garde [c], Aasa Feragen [a]

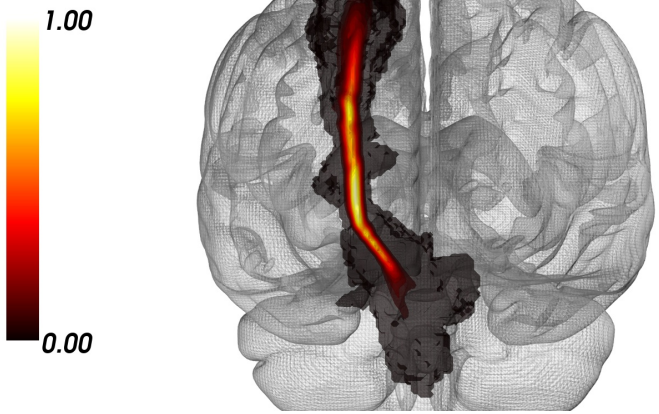


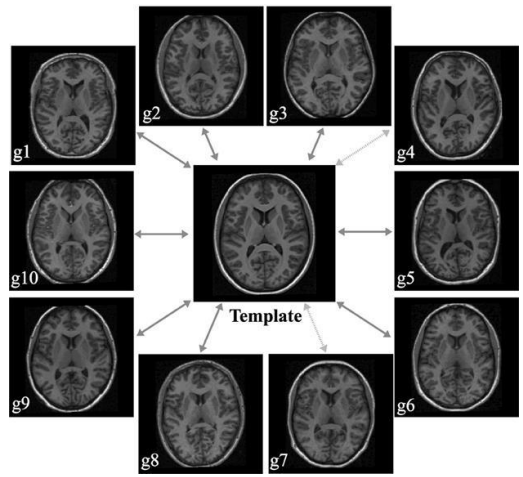
The sky is the limit!

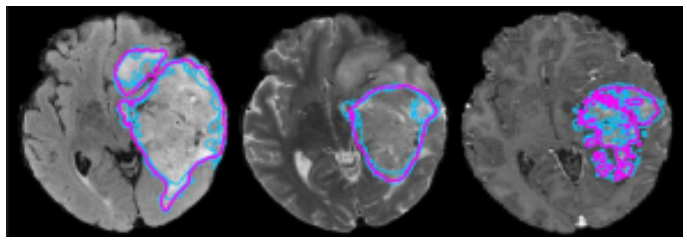
The sky is the limit!

Alas – There are still issues..

Uncertainty quantification. Predictions are good, certain predictions are better, knowing how certain is best

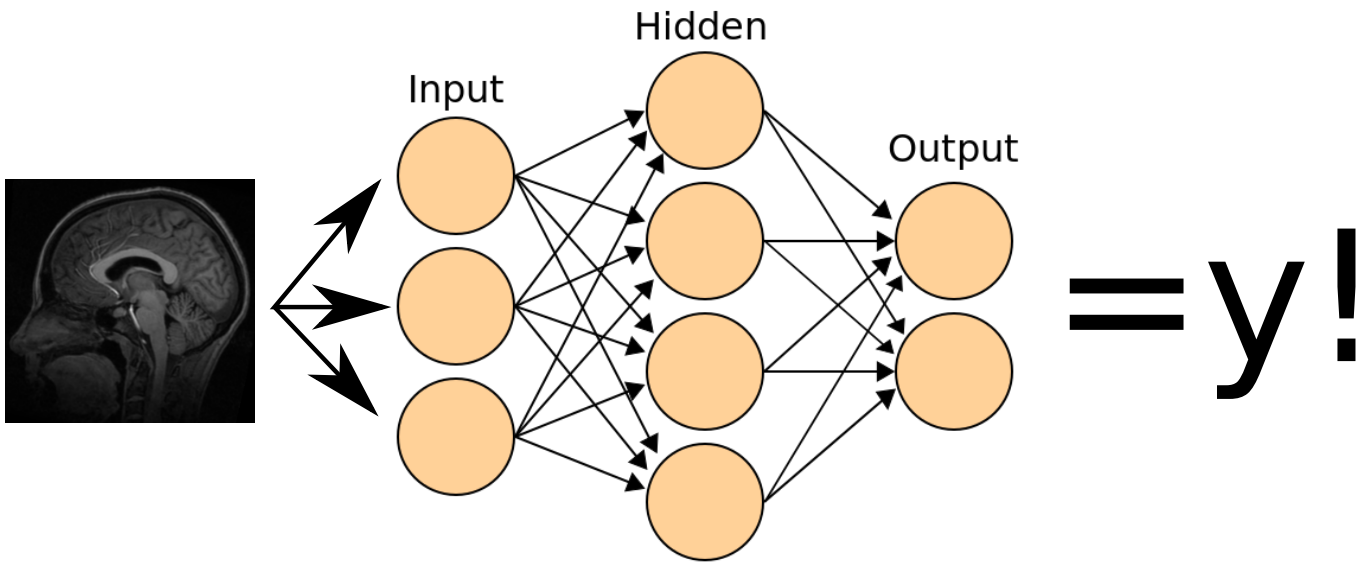






Interpretability and transparency

- Neural networks are largely black box



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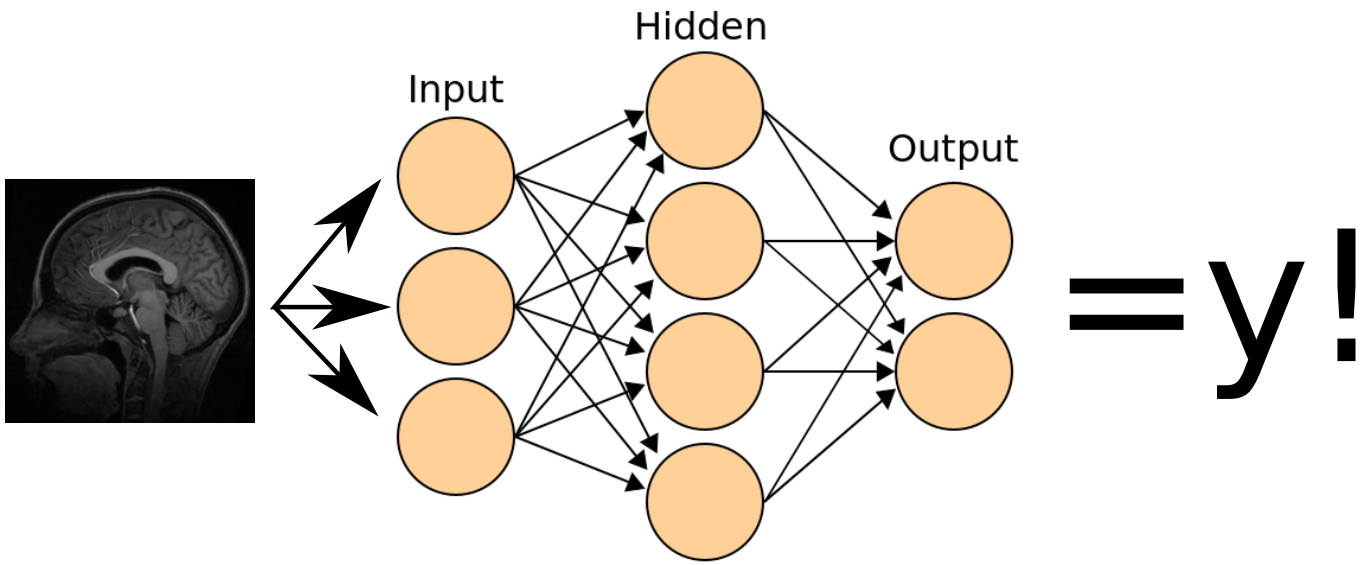
- Neural networks are largely black box
- Diagnosing with good accuracy is great, but knowing what *caused* the diagnosis is even better



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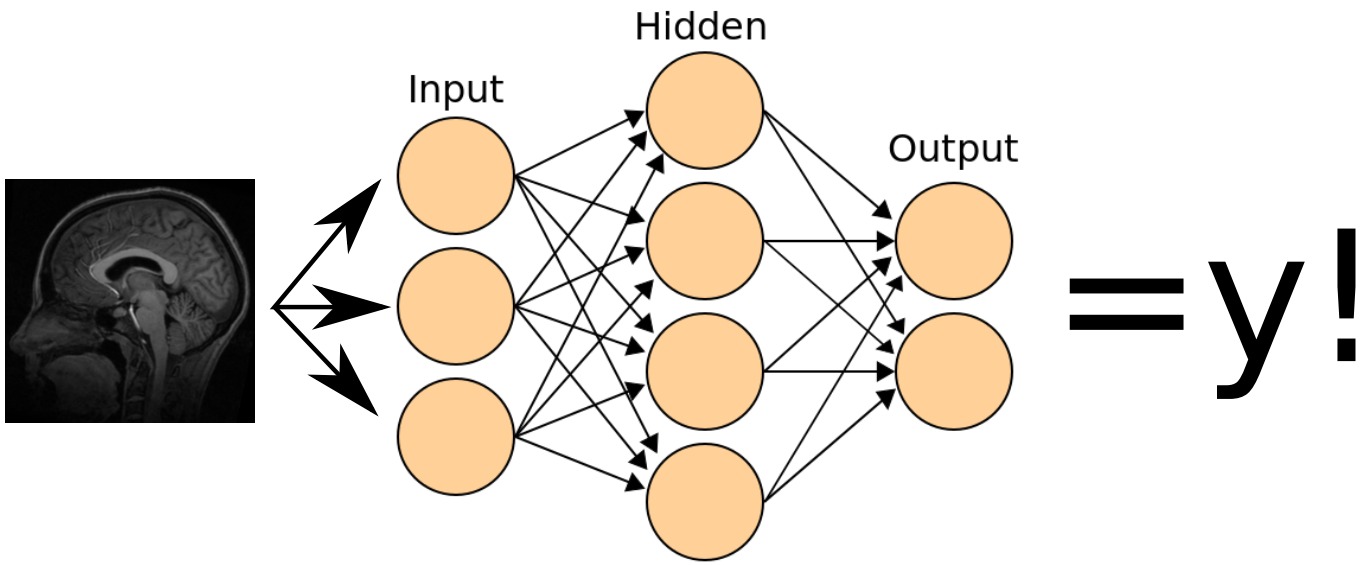
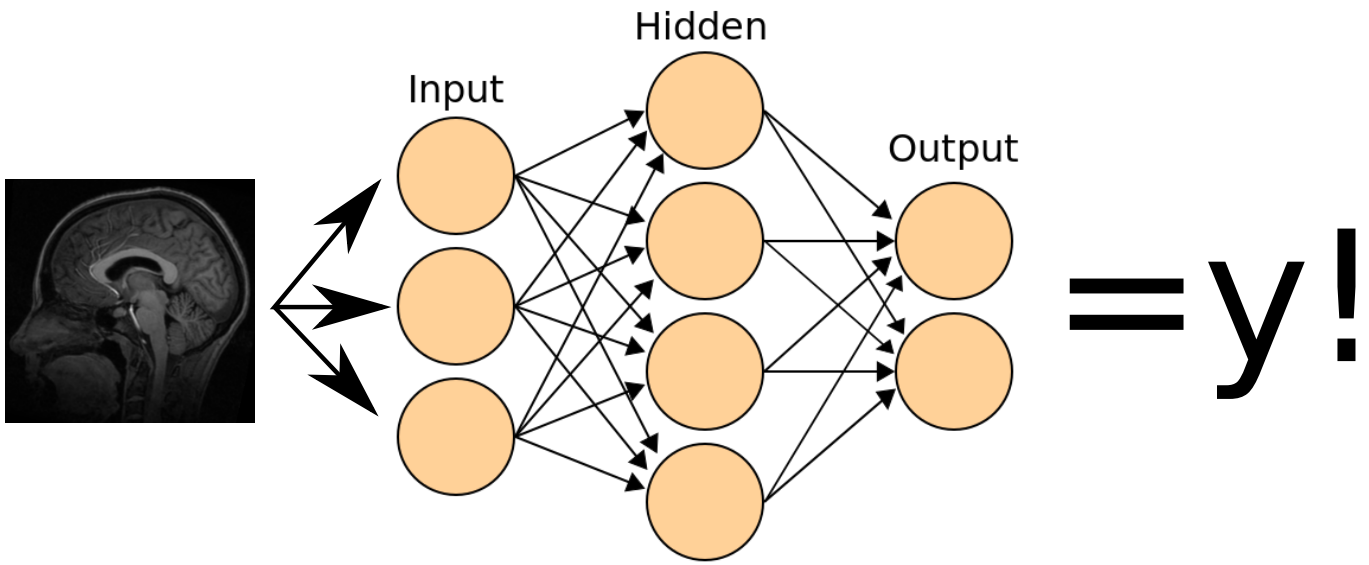
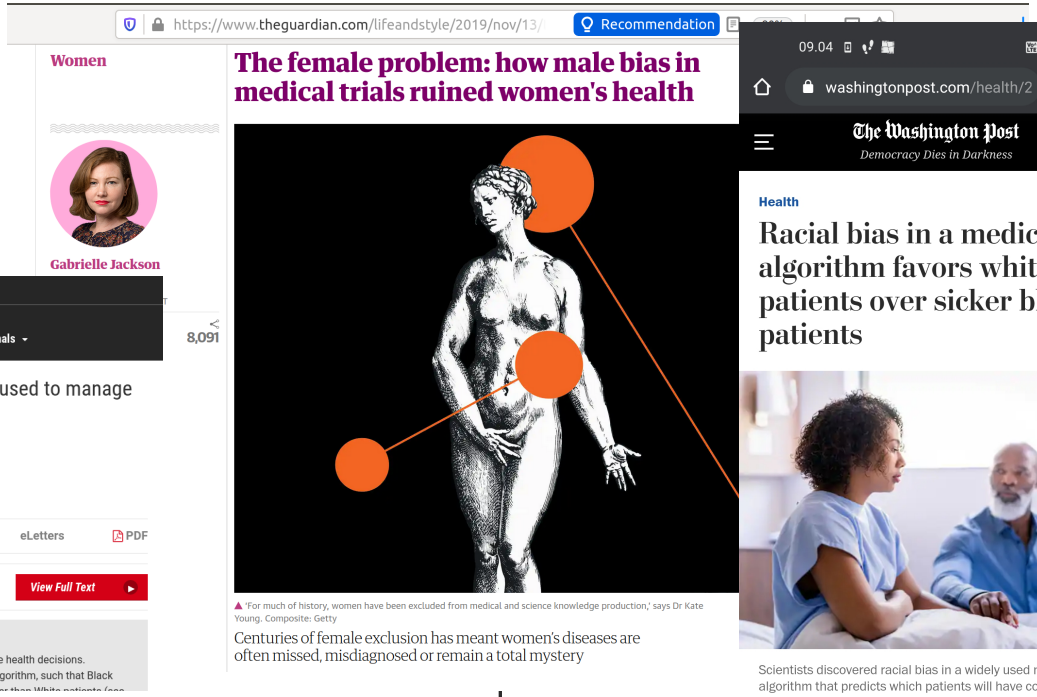


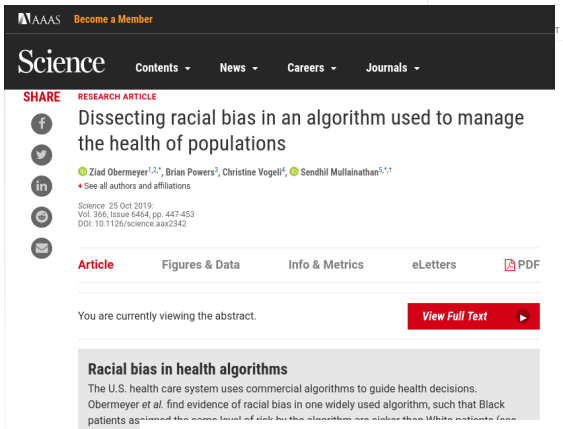
Interpretability and transparency

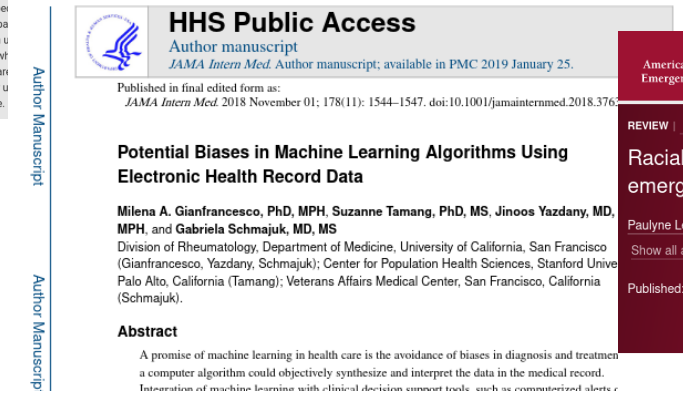
- Neural networks are largely black box
- Diagnosing with good accuracy is great, but knowing what *caused* the diagnosis is even better
- Understanding mistakes are yet even better...
- Model communication, visualization, interaction – important, nontrivial open problems



Bias and Fairness







Bias and Fairness

Sources of bias in ML algorithms:

- Discrimination embedded in training data
- Imbalanced training data

Bias and Fairness

A computer assisted diagnosis example

- State-of-the-art CNN diagnosing thoracic diseases from X-ray[1]
- Increased % females $\Rightarrow$ improved female test diagnosis
- Increased % females $\Rightarrow$ decreased male test diagnosis
- *Predictor trained only on females performs better on men*

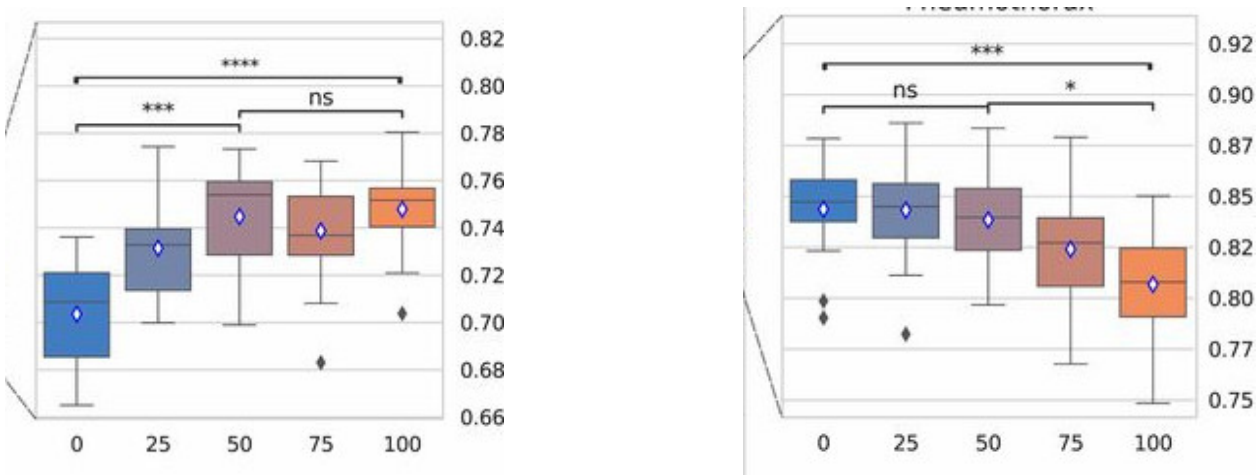


Figure: Diagnostic accuracy of Pneumothorax for female (left) and male (right) test subjects as a function of % females in training set

[1] Larrazabal et al, PNAS 2020

Bias and Fairness

Sources of bias in ML algorithms;

- Discrimination embedded in training data
- Imbalanced training data
- Different levels of label noise (diagnosis errors) give different training conditions for different groups
- Different feature distributions in different groups (different disease patterns and/or anatomical features) give different training conditions for different groups

Outlook

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- At this point, AI is all over – in the scanner, in the processing, in the analysis – working quite well!

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- Is AI just glorified curve fitting? Yes! But if you have a great curve fitter, everything looks like a curve!
- At this point, AI is all over – in the scanner, in the processing, in the analysis – working quite well!
- But there are still pitfalls (and they are very interesting!)
  - Uncertainty modelling/quantification
  - Interpretability/transparency
  - Bias, fairness, ethics – detecting and fixing