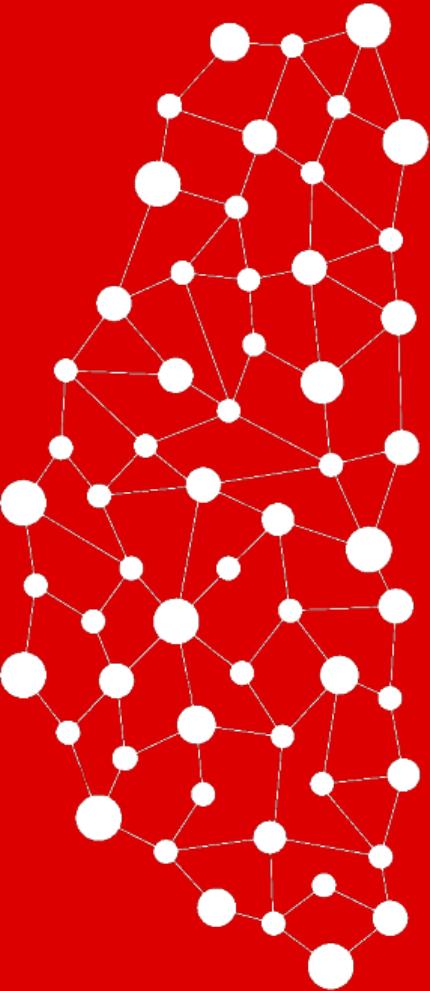
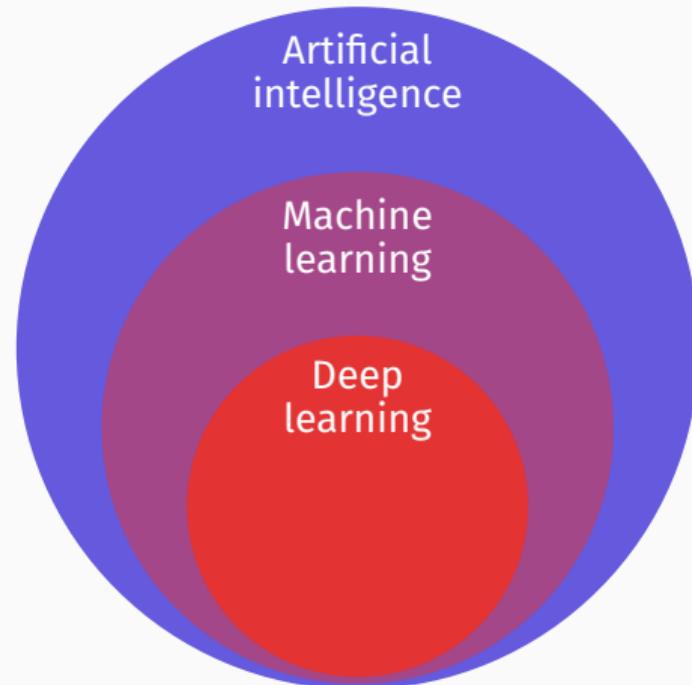


Enabling deep learning in small MRI datasets with transfer learning

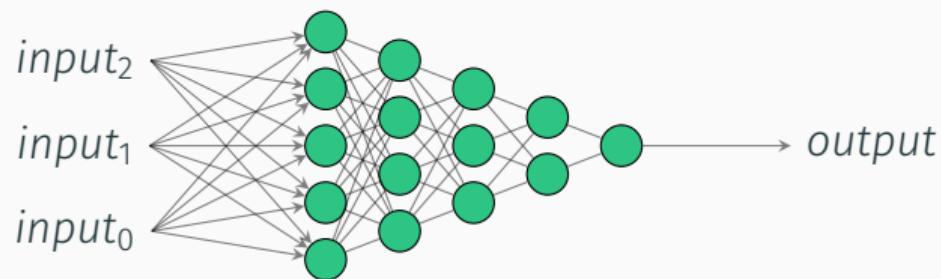


UNIVERSITY
OF OSLO

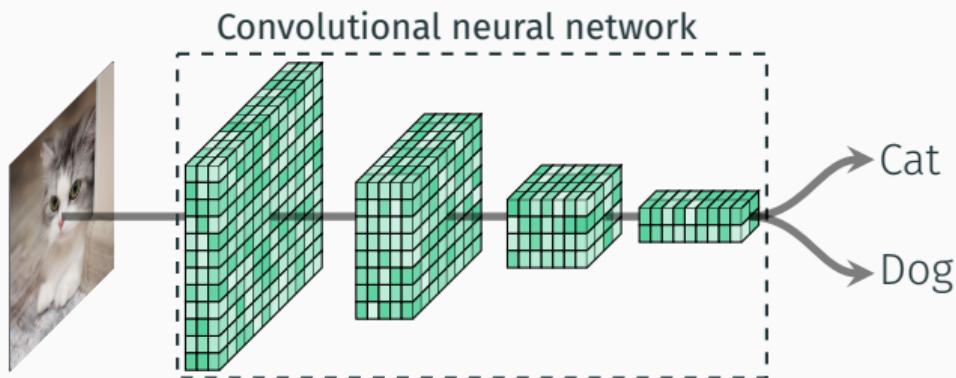
MRI datasets for deep learning



MRI datasets for deep learning



MRI datasets for deep learning



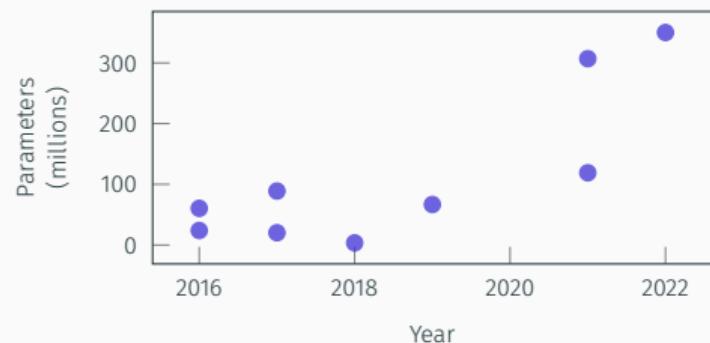
MRI datasets for deep learning

Model	Year	Imagenet top-1 accuracy	Parameters
InceptionV3	2016	77.9%	23.9M
ResNet152V2	2016	78.0%	60.4M
DenseNet201	2017	77.3%	20.2M
NASNetLarge	2017	82.5%	88.9M
MobileNetV2	2018	71.3%	3.5M
EfficientNetB7	2019	84.3%	66.7M
EfficientNetV2L	2021	85.7%	119.0M
Vision Transformer L/16	2021	85.2%	307M
ConvNeXtXLarge	2022	86.3%	350.1M



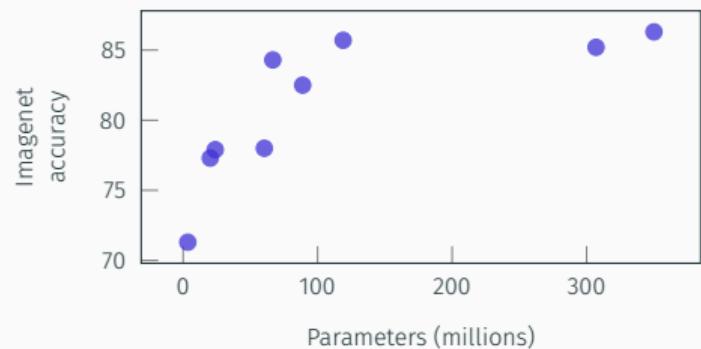
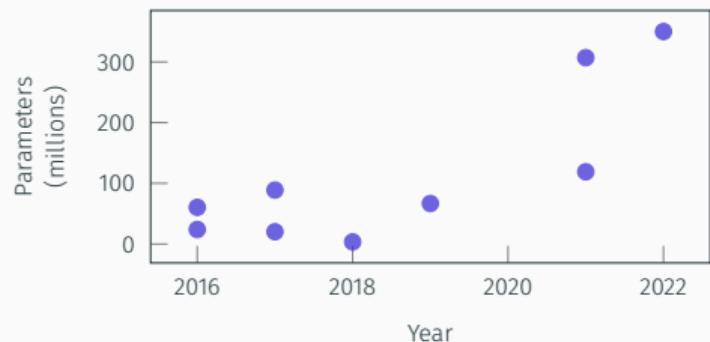
MRI datasets for deep learning

Model	Year	Imagenet top-1 accuracy	Parameters
InceptionV3	2016	77.9%	23.9M
ResNet152V2	2016	78.0%	60.4M
DenseNet201	2017	77.3%	20.2M
NASNetLarge	2017	82.5%	88.9M
MobileNetV2	2018	71.3%	3.5M
EfficientNetB7	2019	84.3%	66.7M
EfficientNetV2L	2021	85.7%	119.0M
Vision Transformer L/16	2021	85.2%	307M
ConvNeXtXLarge	2022	86.3%	350.1M



MRI datasets for deep learning

Model	Year	Imagenet top-1 accuracy	Parameters
InceptionV3	2016	77.9%	23.9M
ResNet152V2	2016	78.0%	60.4M
DenseNet201	2017	77.3%	20.2M
NASNetLarge	2017	82.5%	88.9M
MobileNetV2	2018	71.3%	3.5M
EfficientNetB7	2019	84.3%	66.7M
EfficientNetV2L	2021	85.7%	119.0M
Vision Transformer L/16	2021	85.2%	307M
ConvNeXtXLarge	2022	86.3%	350.1M



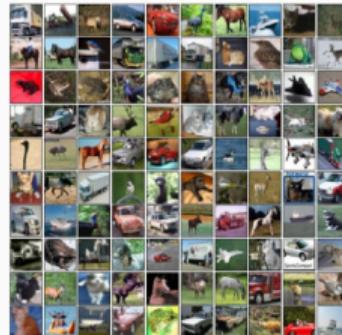
MRI datasets for deep learning

Dataset	Size	Dimensionality
MNIST	~70K	28x28 pixels



MRI datasets for deep learning

Dataset	Size	Dimensionality
MNIST	~70K	28x28 pixels
CIFAR	~60K	32x32 pixels



MRI datasets for deep learning

Dataset	Size	Dimensionality
MNIST	~70K	28x28 pixels
CIFAR	~60K	32x32 pixels
COCO	~330K	640x640 pixels
ImageNet (21k)	~14M	224x224 pixels



MRI datasets for deep learning

Dataset	Size	Dimensionality
MNIST	~70K	28x28 pixels
CIFAR	~60K	32x32 pixels
COCO	~330K	640x640 pixels
ImageNet (21k)	~14M	224x224 pixels
CLIP	~400M	224x224 pixels
JFT-3B	~3B	256x256 pixels
LAION-5B	~2.3B	336x336 pixels



C: Green Apple Chair



C: sun snow dog



C: Color Palettes



C: pink, japan, aesthetic image



MRI datasets for deep learning

Dataset	Size	Dimensionality
MNIST	~70K	28x28 pixels
CIFAR	~60K	32x32 pixels
COCO	~330K	640x640 pixels
ImageNet (21k)	~14M	224x224 pixels
CLIP	~400M	224x224 pixels
JFT-3B	~3B	256x256 pixels
LAION-5B	~2.3B	336x336 pixels

UK Biobank	45,891	256x256x256 voxels
ABCD	11,660	256x256x256 voxels
ADNI	2,729	256x256x256 voxels
TOP	2,222	256x256x256 voxels
HBN	1,365	256x256x256 voxels
QTIM	1,201	256x256x256 voxels
PING	1,176	256x256x256 voxels
CoRR	1,156	256x256x256 voxels
HCP	1,113	256x256x256 voxels
OASIS3	1,062	256x256x256 voxels



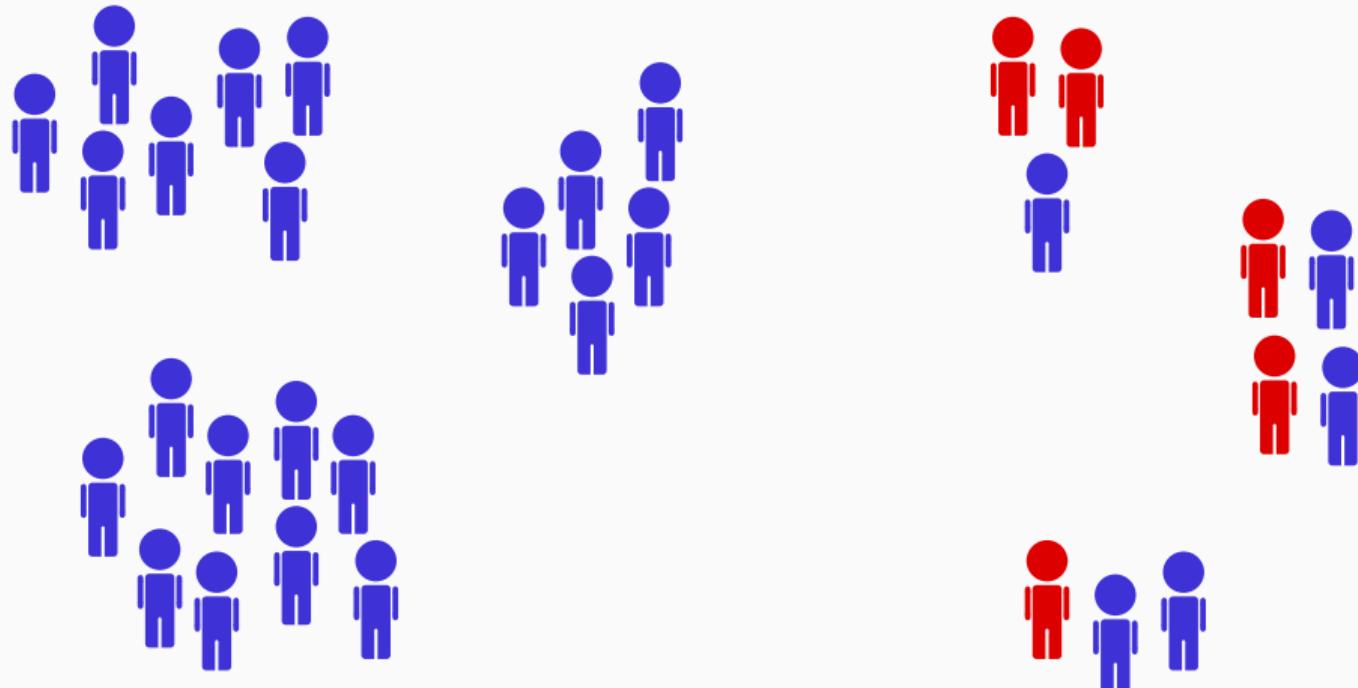
MRI datasets for deep learning

Dataset	Size	Dimensionality
MNIST	~70K	28x28 pixels
CIFAR	~60K	32x32 pixels
COCO	~330K	640x640 pixels
ImageNet (21k)	~14M	224x224 pixels
CLIP	~400M	224x224 pixels
JFT-3B	~3B	256x256 pixels
LAION-5B	~2.3B	336x336 pixels

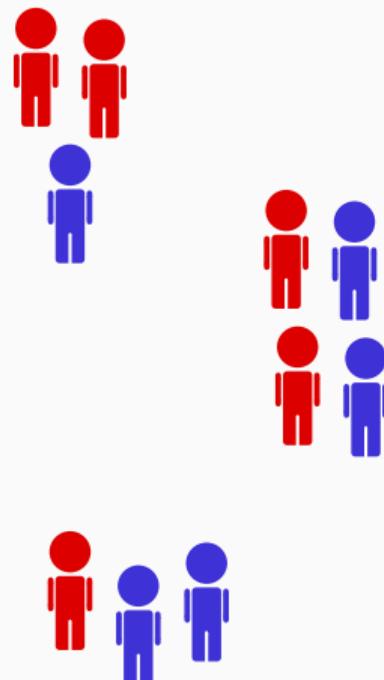
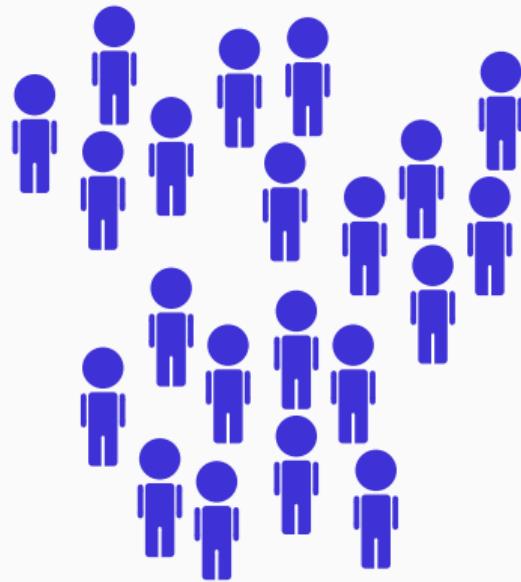
UK Biobank	45,891	256x256x256 voxels
ABCD	11,660	256x256x256 voxels
ADNI	2,729	256x256x256 voxels
TOP	2,222	256x256x256 voxels
HBN	1,365	256x256x256 voxels
QTIM	1,201	256x256x256 voxels
PING	1,176	256x256x256 voxels
CoRR	1,156	256x256x256 voxels
HCP	1,113	256x256x256 voxels
OASIS3	1,062	256x256x256 voxels



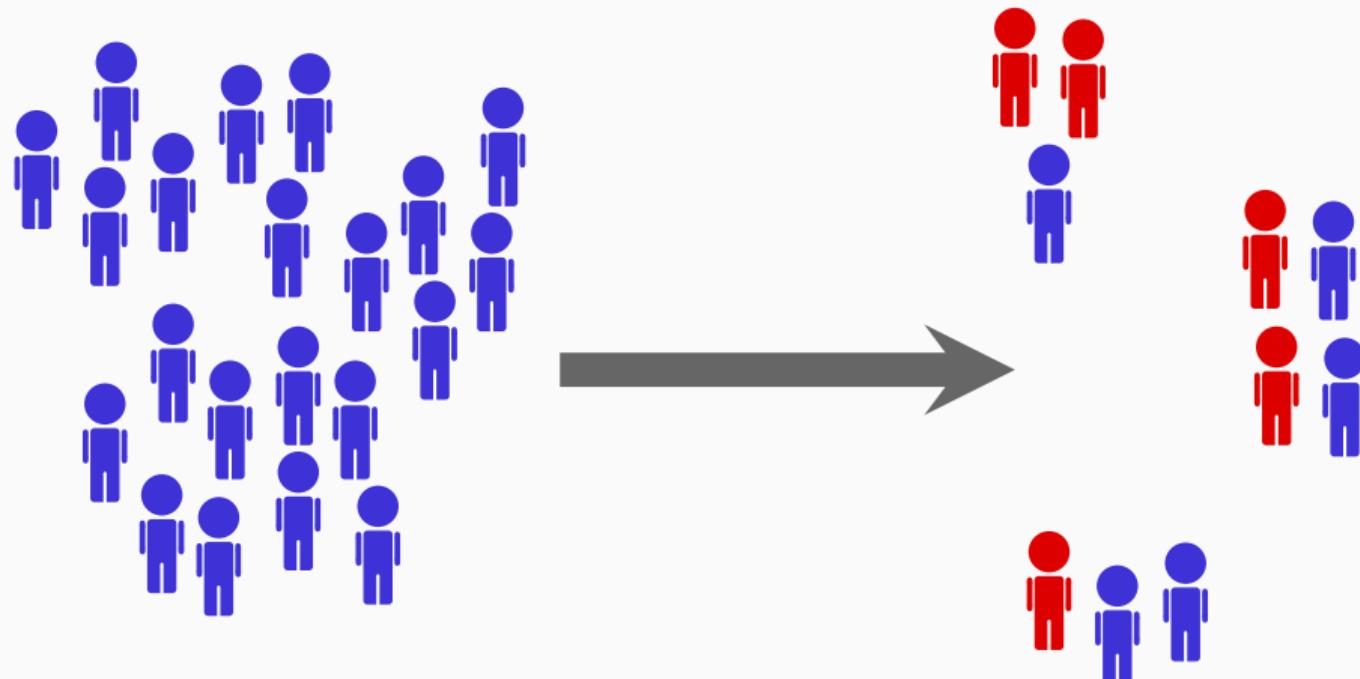
MRI datasets for deep learning



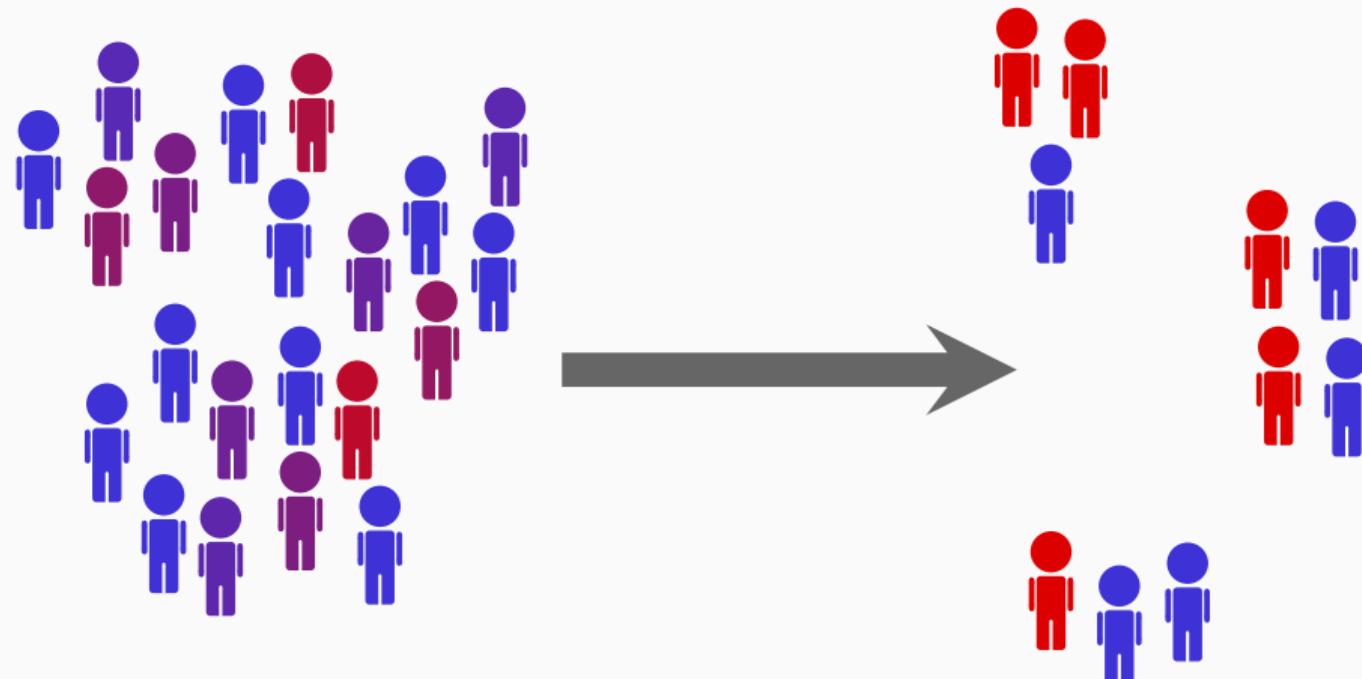
MRI datasets for deep learning



MRI datasets for deep learning



MRI datasets for deep learning

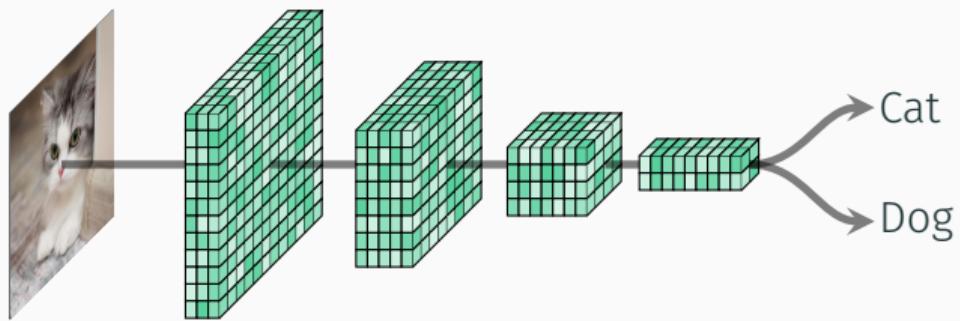


Transfer learning

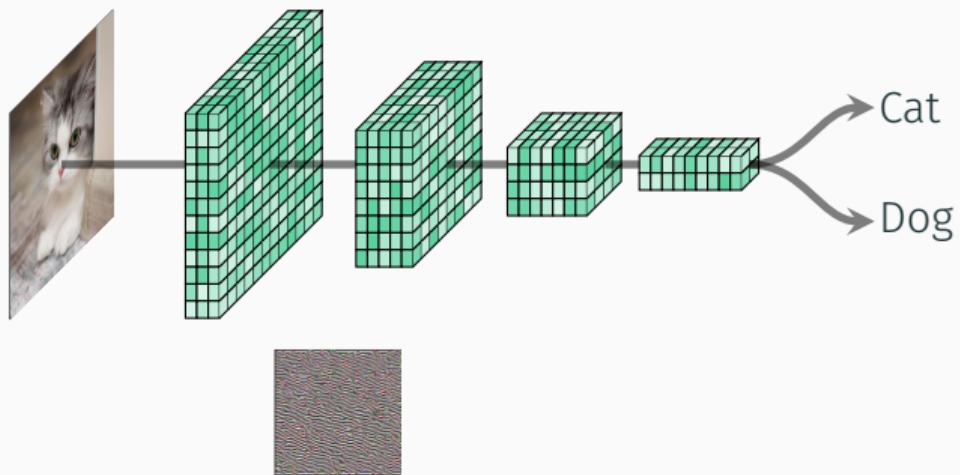


UNIVERSITETET
I OSLO

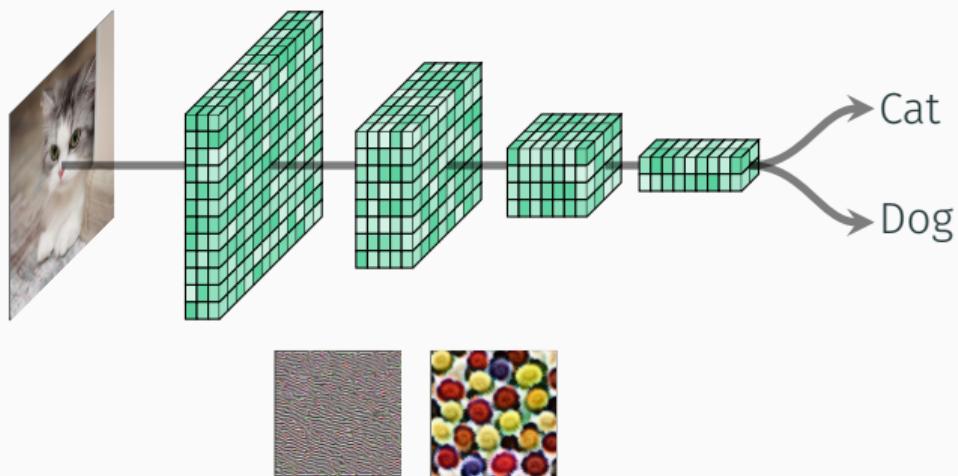
How does CNNs work



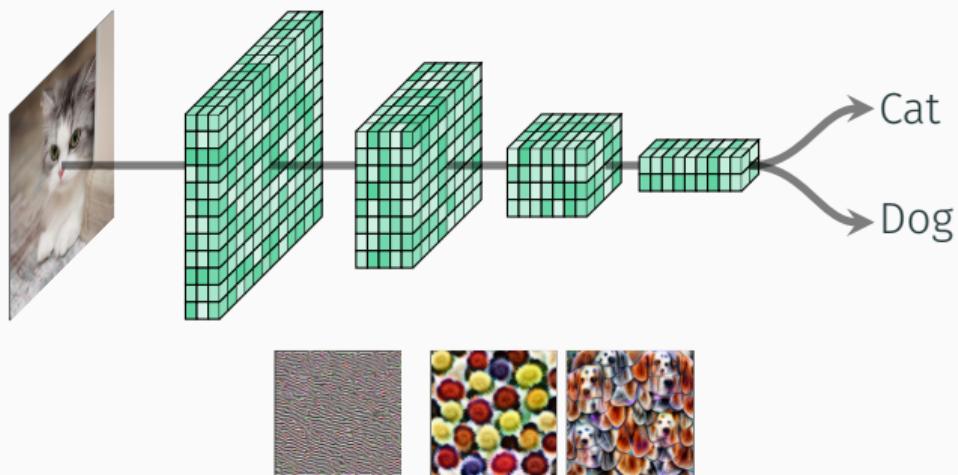
How does CNNs work



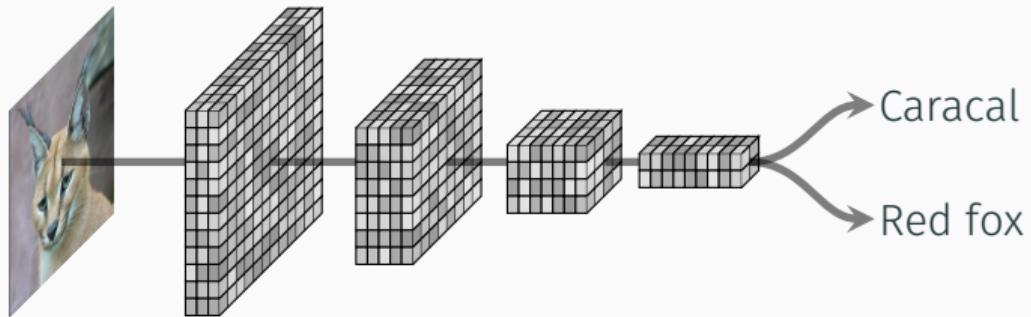
How does CNNs work



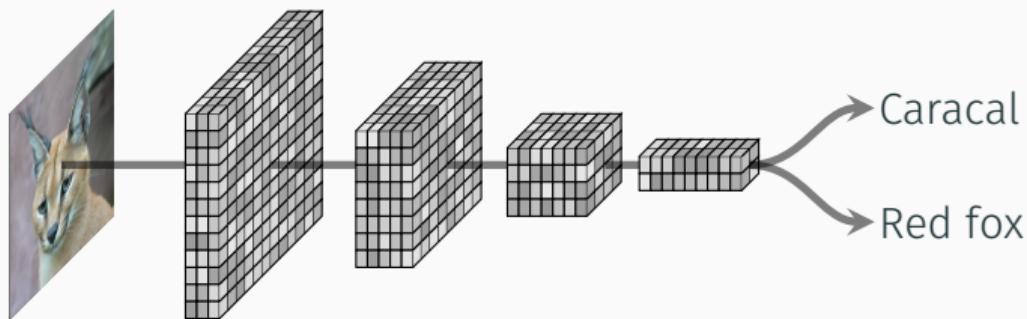
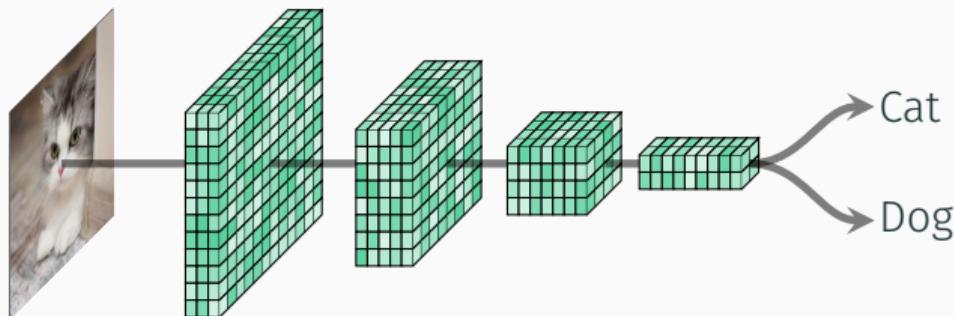
How does CNNs work



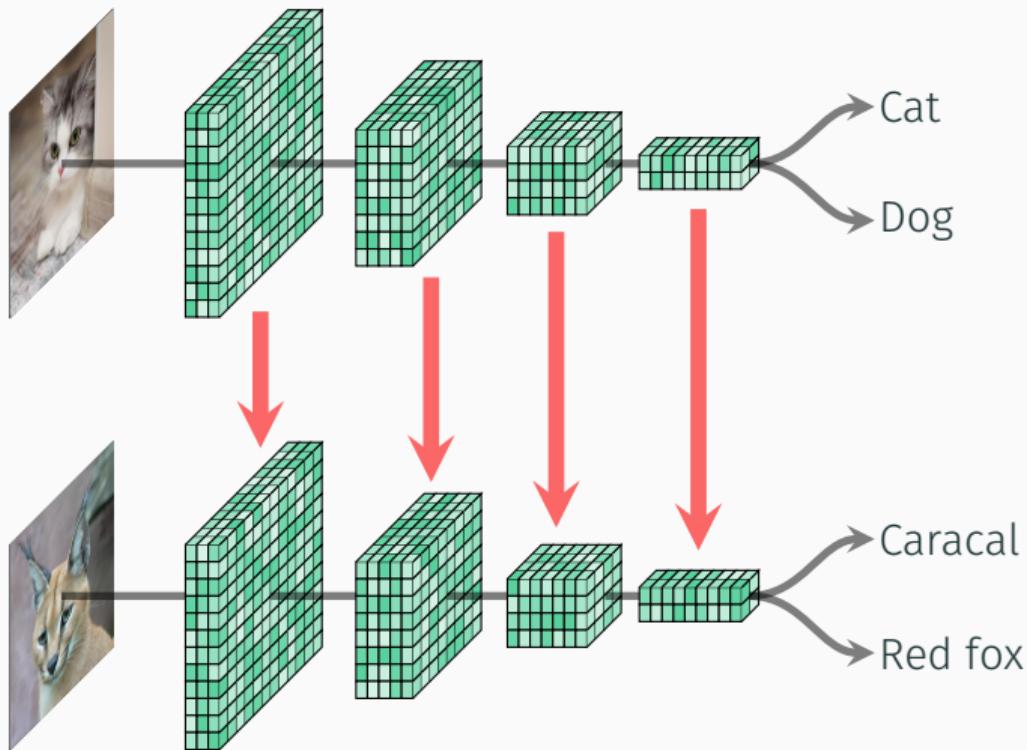
Transfer learning



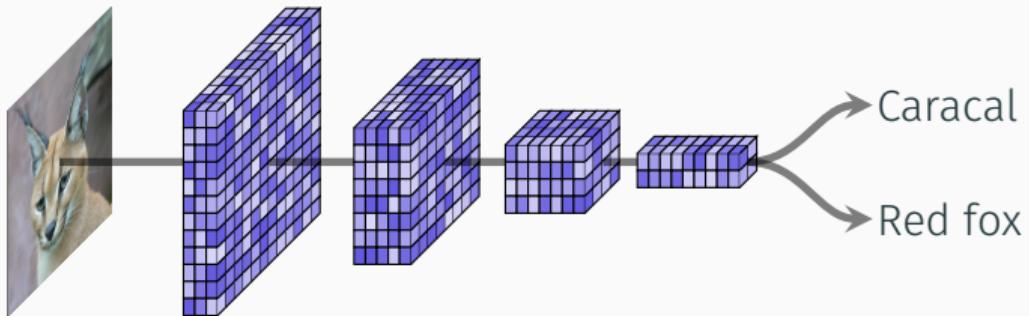
Transfer learning



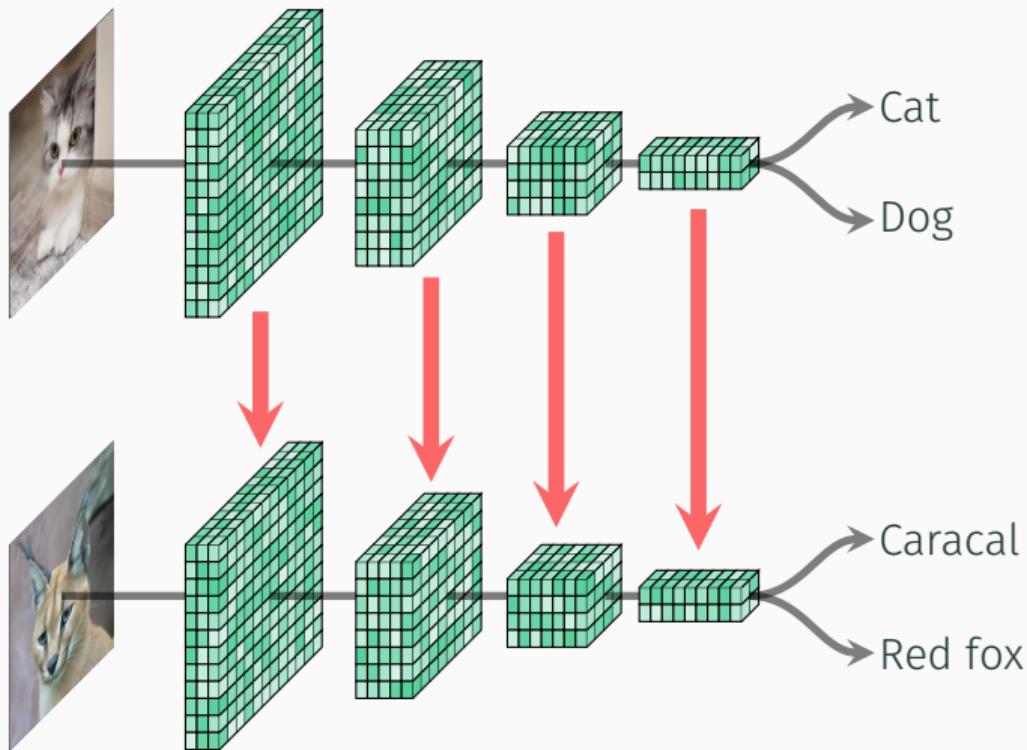
Transfer learning



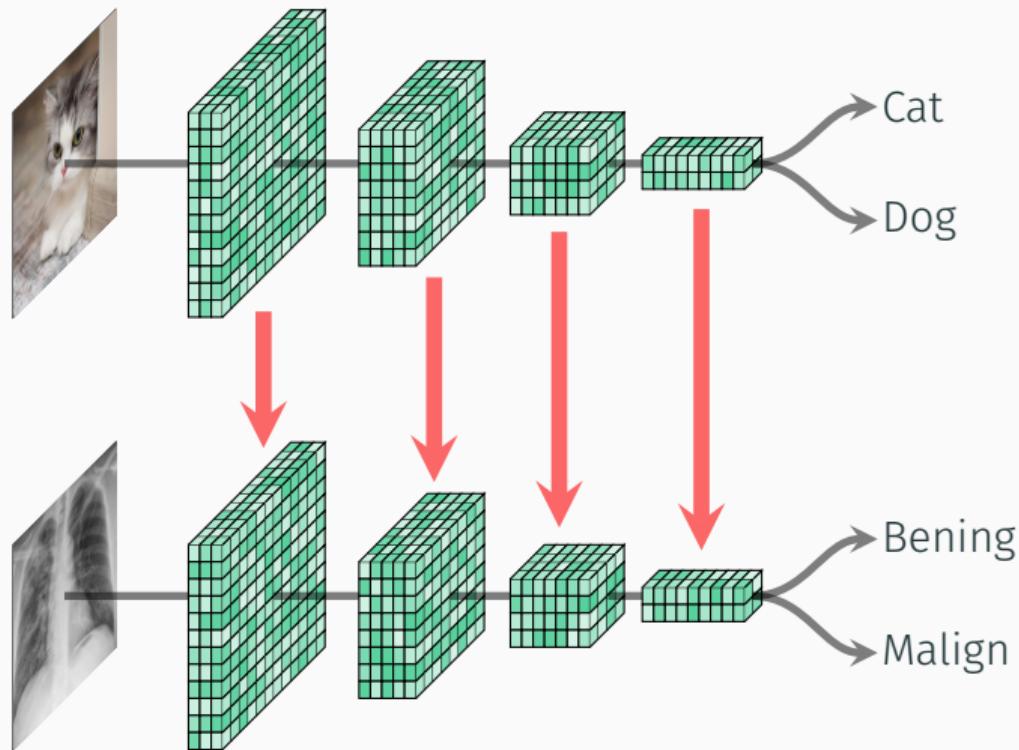
Transfer learning



Transfer learning



Transfer learning

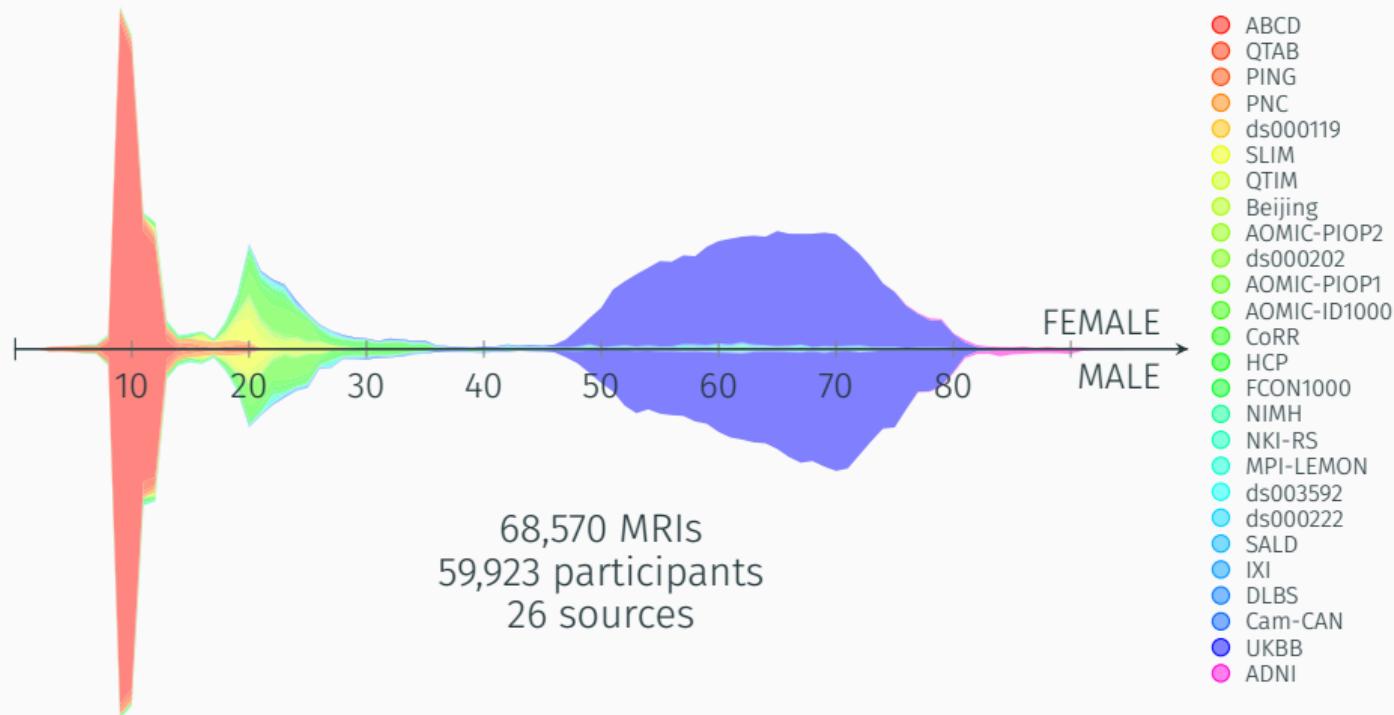


Our work

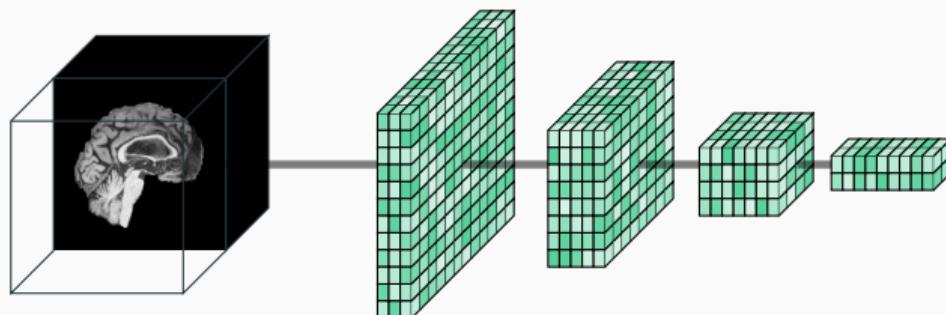


UNIVERSITETET
I OSLO

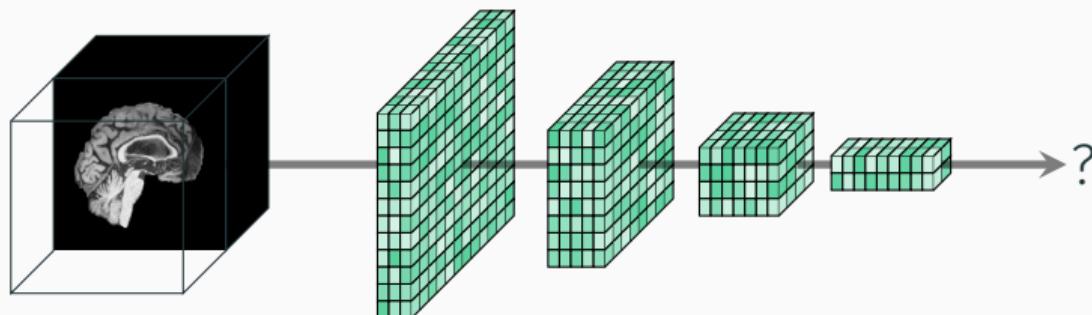
Methods: Training dataset



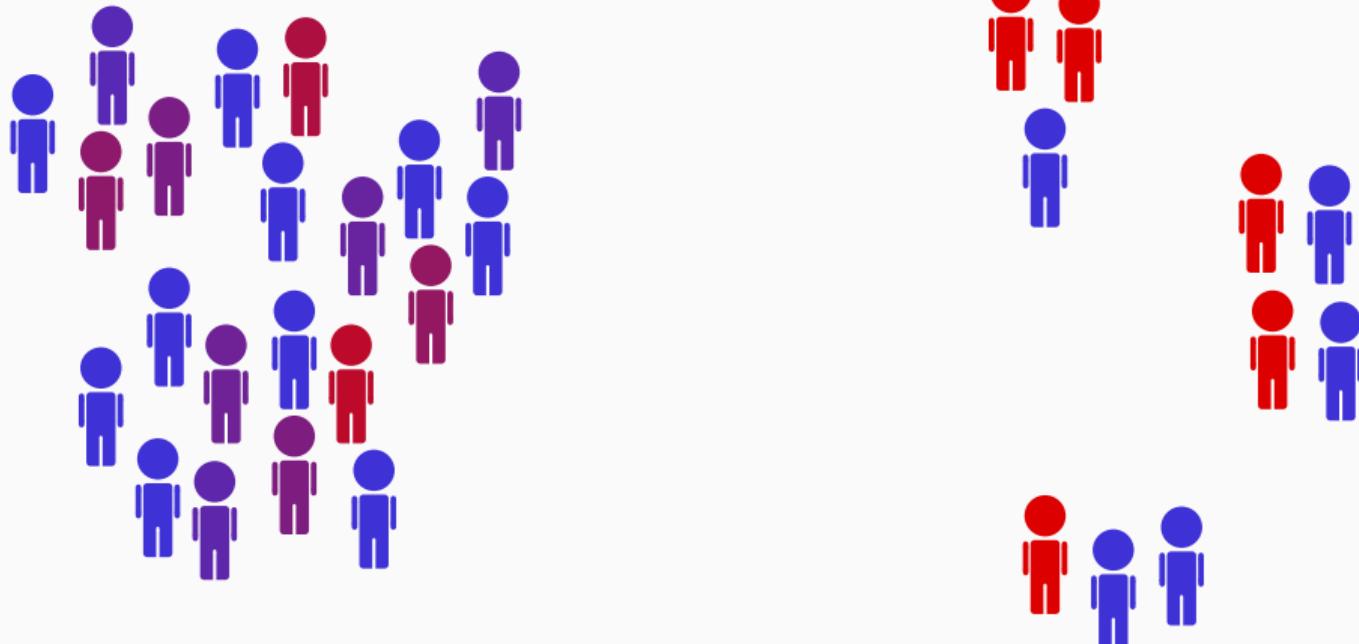
Methods: Modelling



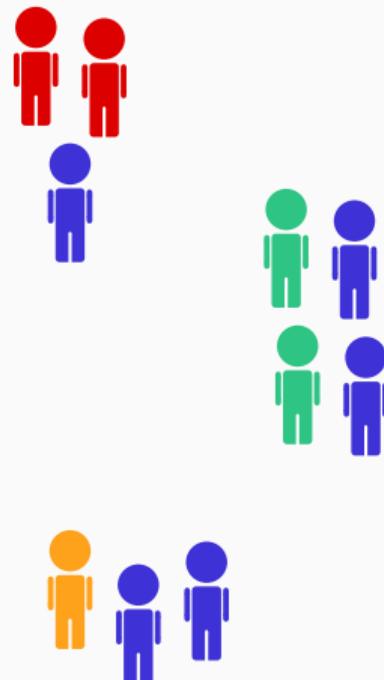
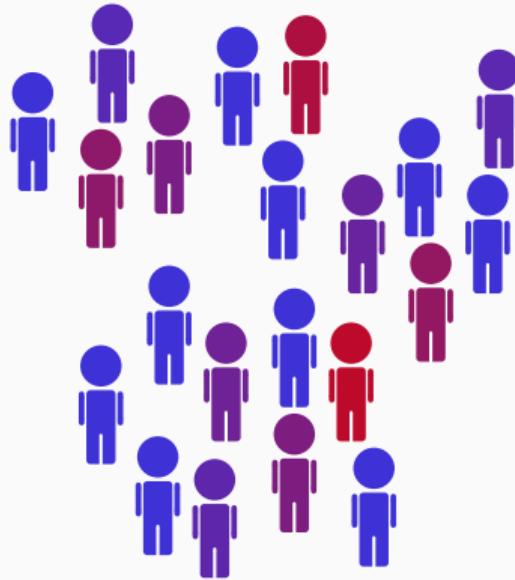
Methods: Modelling



Methods: Modelling



Methods: Modelling



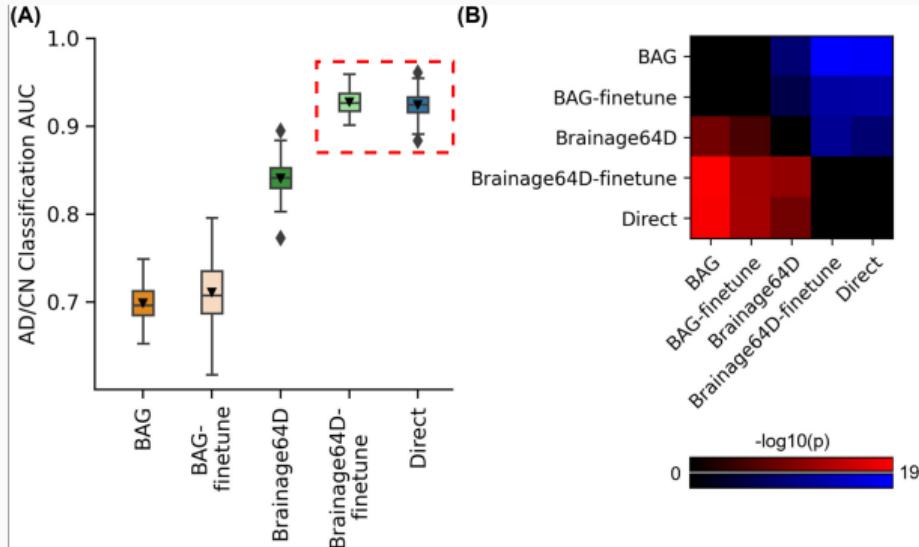
Methods: Modelling

Furthermore, we see this result as evidence that deep learning models trained to predict age in large multisite datasets constitute excellent starting points for transfer learning, which can subsequently be fine-tuned to a variety of tasks.

Leonardsen, E. H., Peng, H., Kaufmann, T., Agartz, I., Andreassen, O. A., Celius, E. G., ... & Wang, Y. (2022). Deep neural networks learn general and clinically relevant representations of the ageing brain. *NeuroImage*, 256, 119210.



Methods: Modelling



Tan, T. W. K., Nguyen, K. N., Zhang, C., Kong, R., Cheng, S. F., Ji, F., ... & Australian Imaging Biomarkers and Lifestyle Study of Aging. (2025). Mind the gap: Does brain age improve Alzheimer's disease prediction? *Human Brain Mapping*, 46(12), e70276.



Methods: Modelling

Brain age



Methods: Modelling

Brain age

Self-supervised
approaches



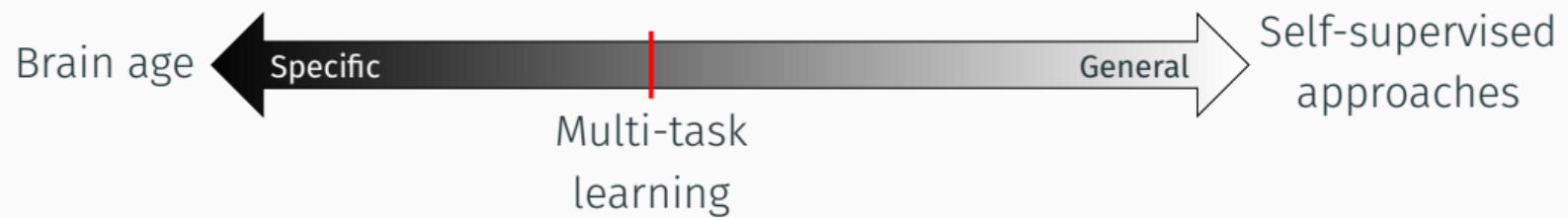
Methods: Modelling



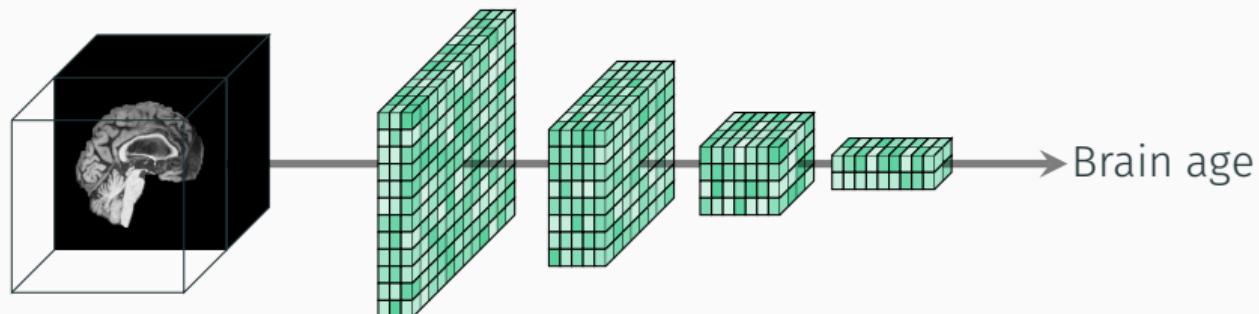
Methods: Modelling



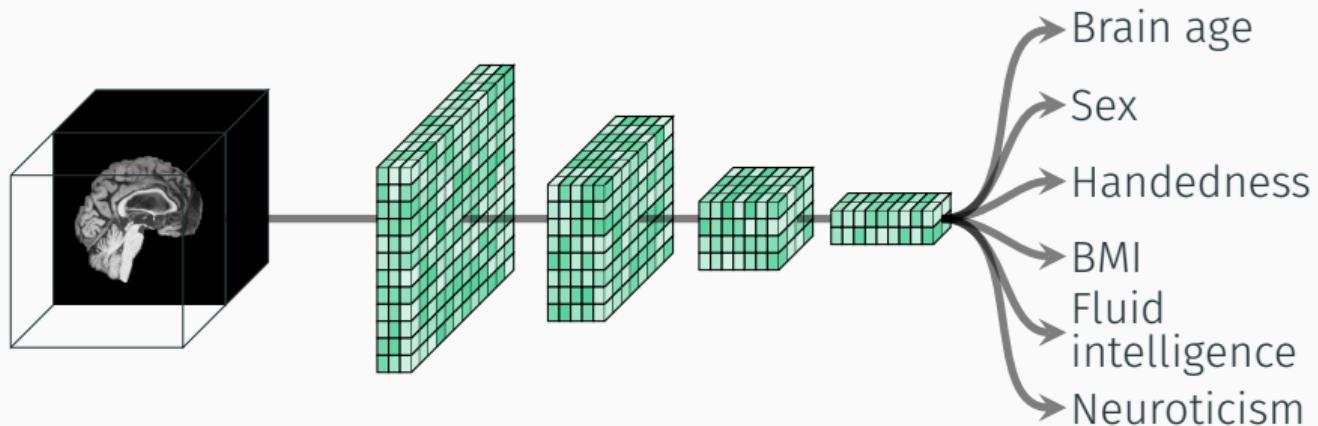
Methods: Modelling



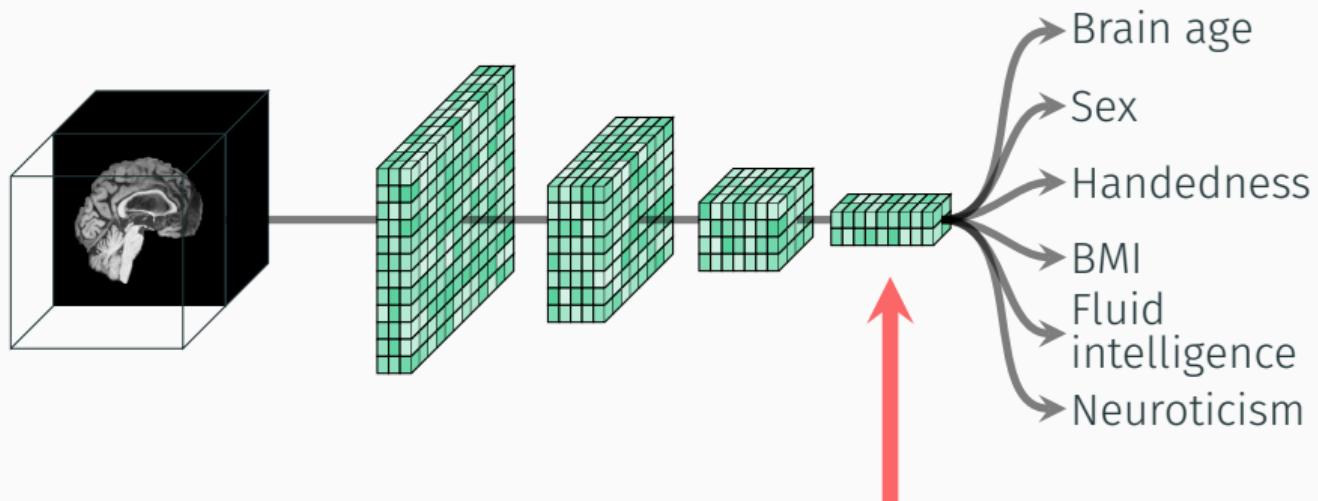
Methods: Multi-task learning



Methods: Multi-task learning



Methods: Multi-task learning



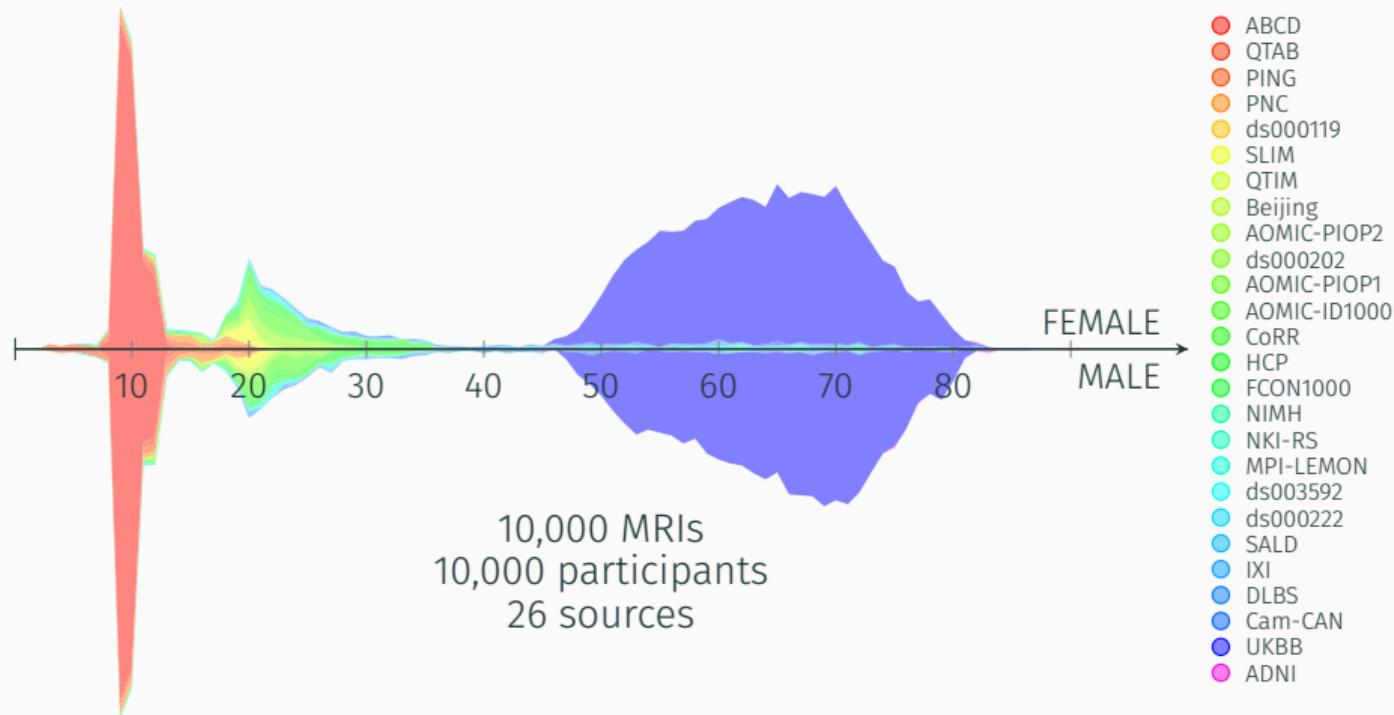
Methods: Multi-task learning



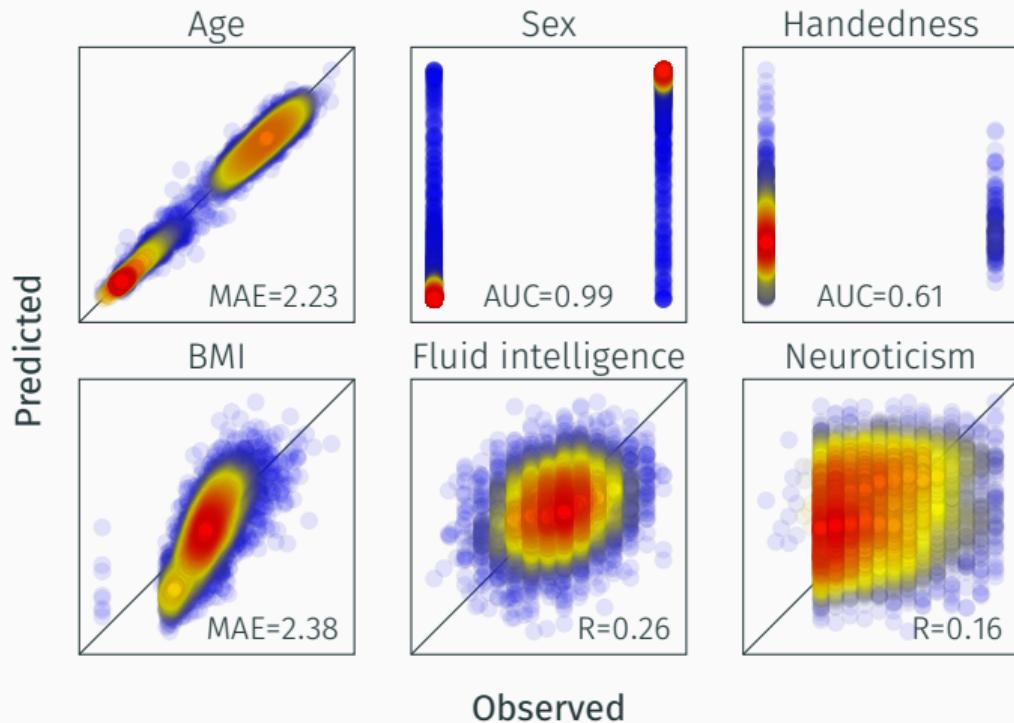
Age	1	0	0.02	0.52	-0.1	-0.04
Sex	0	1	0.03	0.04	-0.15	0.04
Handedness	-0.02	0.03	1	0	0.03	-0.03
BMI	0.52	0.04	0	1	-0.03	-0.05
Fluid intelligence	-0.1	-0.15	0.03	-0.03	1	-0.04
Neuroticism	-0.04	0.04	-0.03	-0.05	-0.04	1



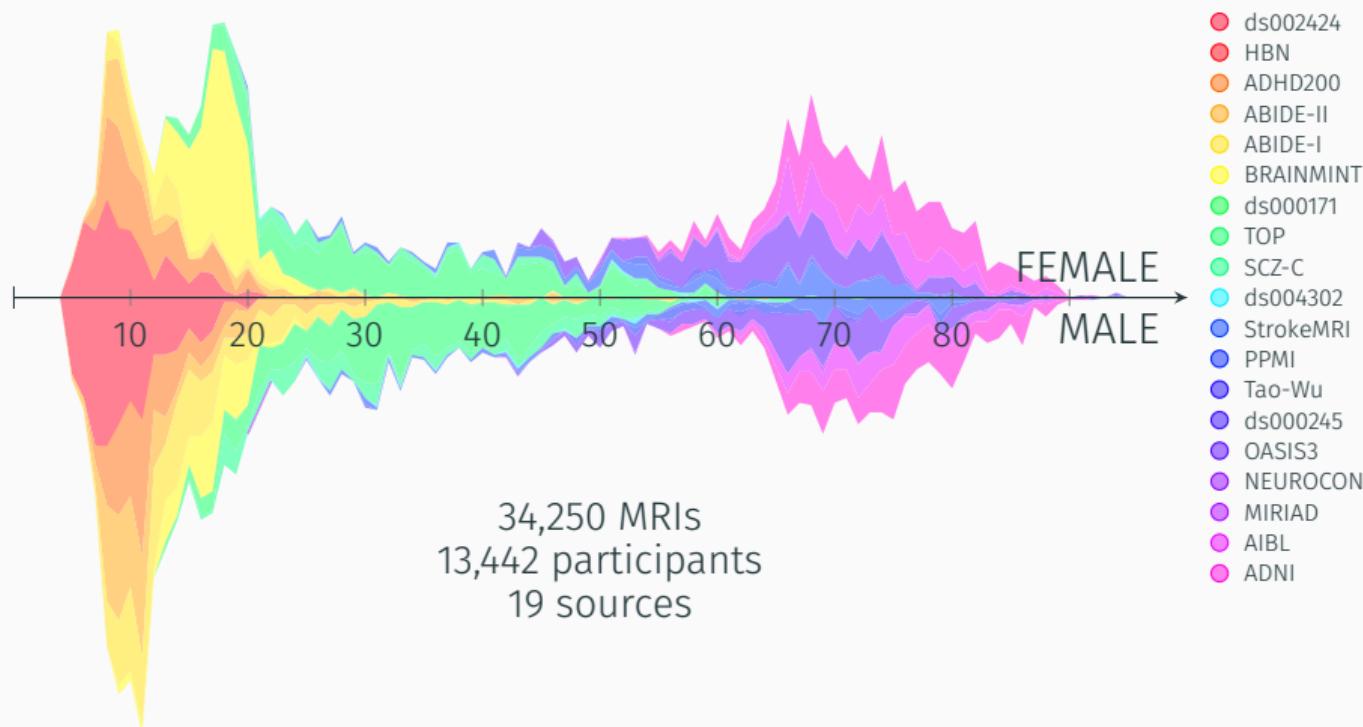
Results: Validation



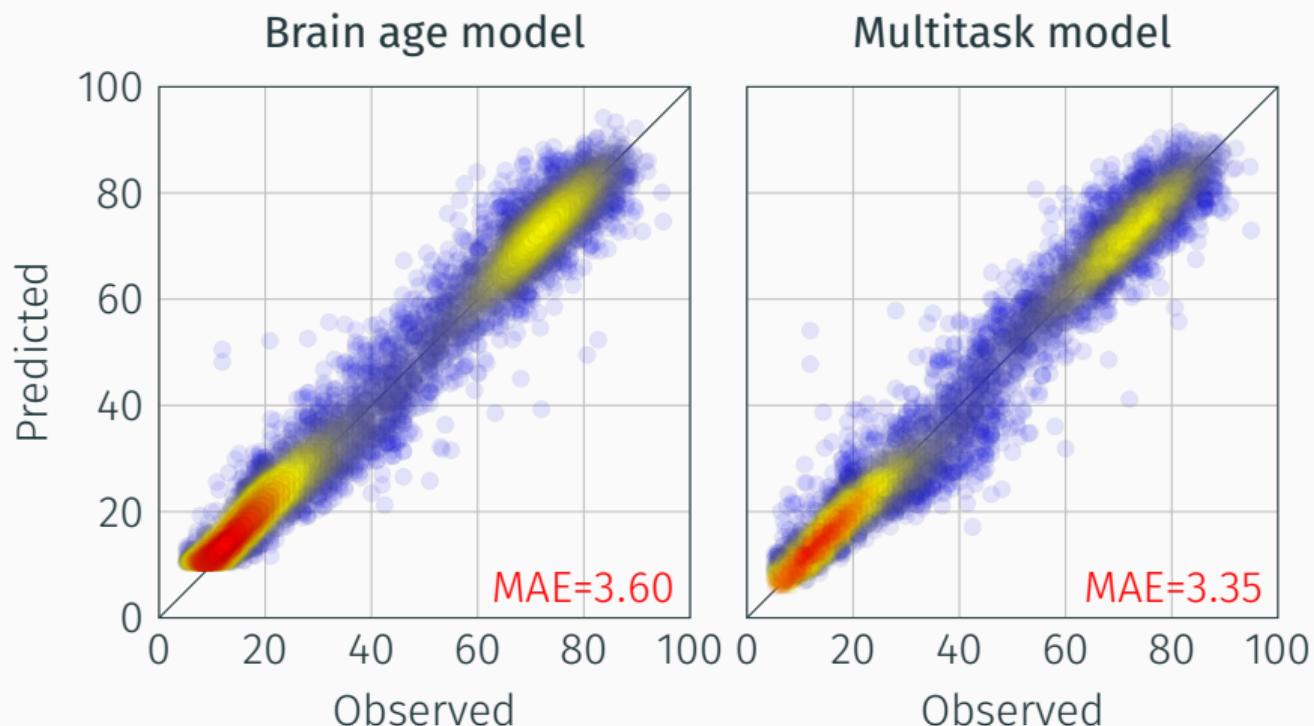
Results: Validation



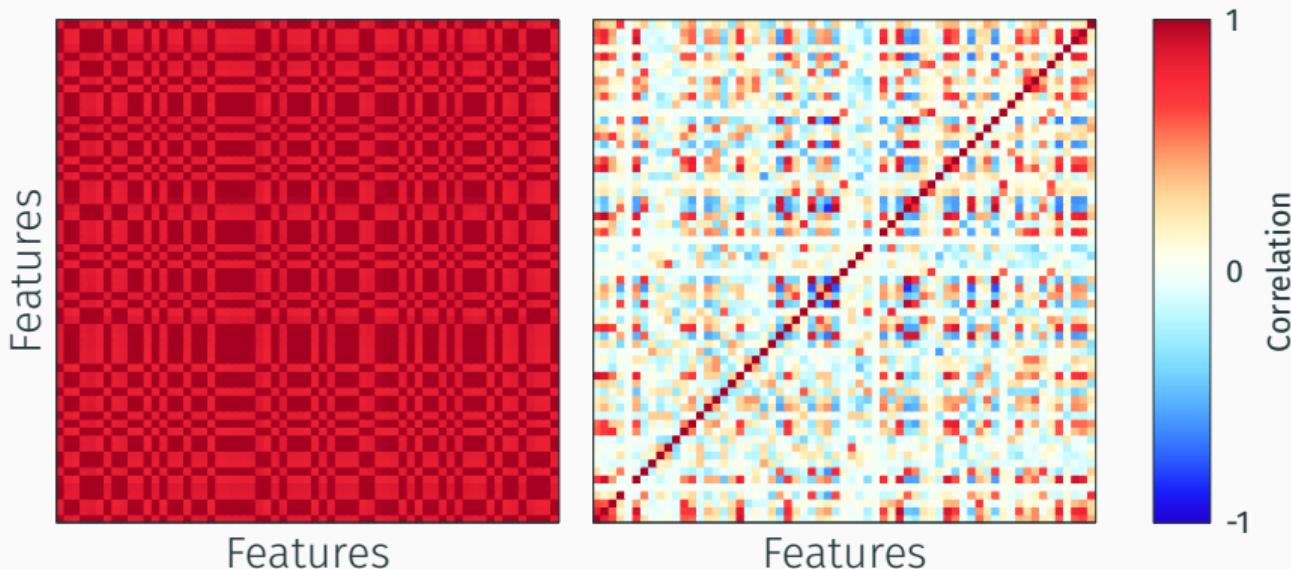
Results: Brain age



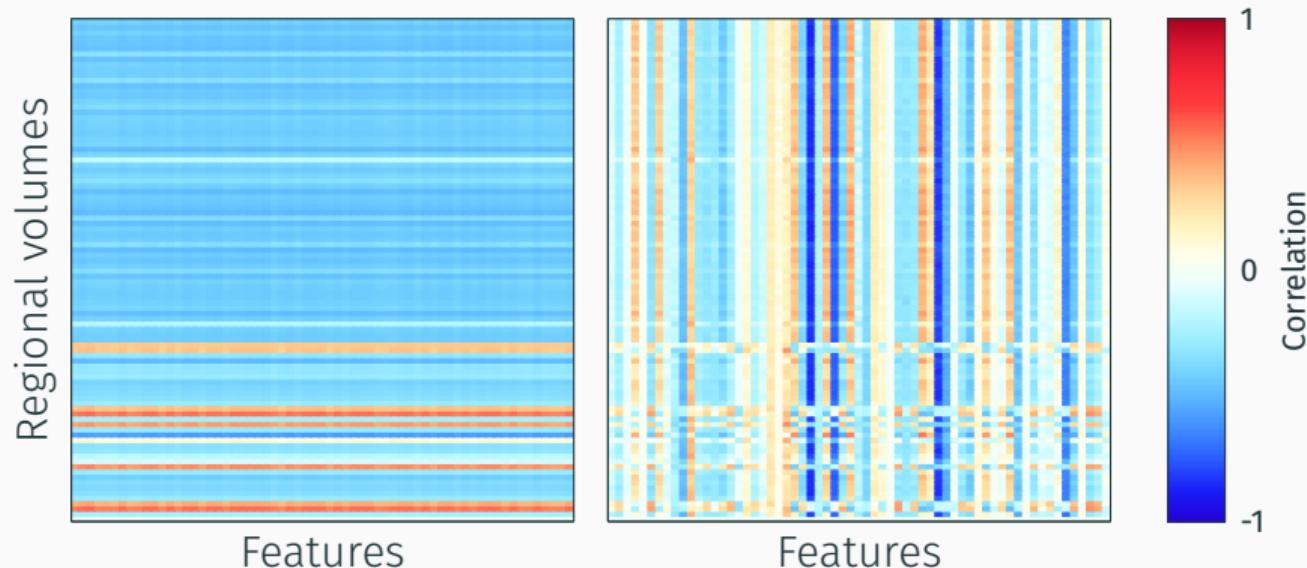
Results: Brain age



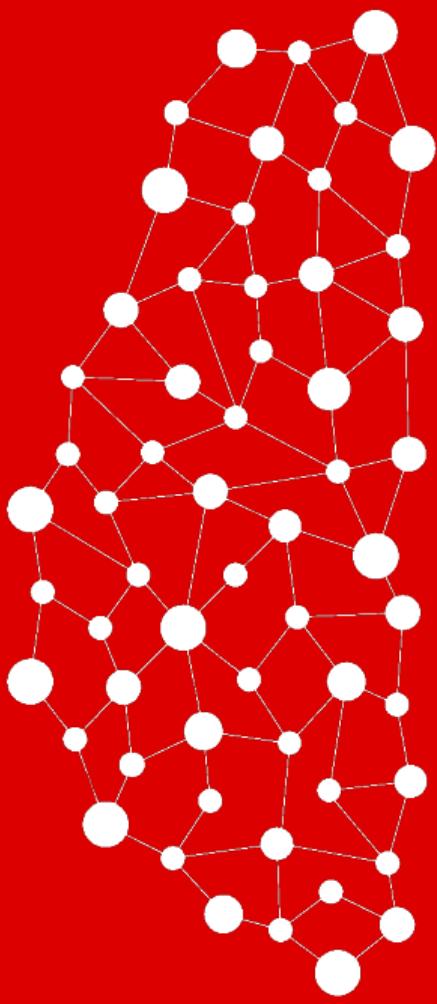
Results: Feature spaces



Results: Feature spaces



Thank you for your attention!
estenhl@ui.no



UNIVERSITY
OF OSLO