BrainWatchers

Capstone Project presentation

08.09.2022

The BrainWatcher's team

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Mathematician

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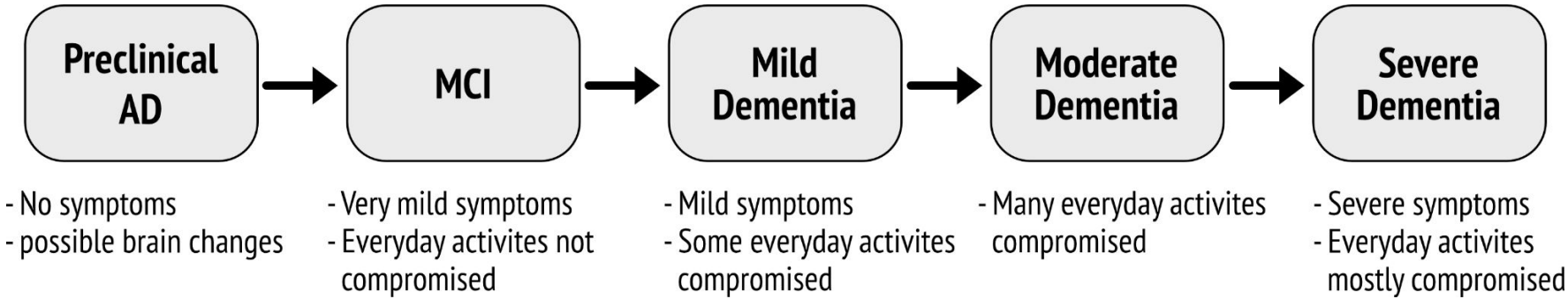
Biochemist

Introduction - Alzheimer's disease (AD)

- progressive brain disease
- Symptoms: apathy, depression, disorientation, behavioural changes



MCI - mild cognitive impairment

Diagnosis of Alzheimer's disease

Some common diagnostic methods include:

- Cognitive assessment test (e.g. MMSE) (**non-invasive**)
- Brain scans (e.g. MRI, PET or CT) (**non-invasive**)
- Spinal fluid biomarker protein analysis (**invasive**)

How good are doctors in predicting Alzheimer's based on MRI images? (Lombardi et al. 2020)

Correct classifications = 72%

Fraction of missed demented cases = 27%

Our aim

Develop a robust model that can predict Alzheimer's based on MRI images.

Who would use our model?

Neurologists

What the model could help with:

- Provide a second opinion about the diagnosis
- Save money and time for further tests

Datasets

OASIS *(oasis-brains.org)*

- 2D and 3D MRI images of 416 subjects
- Demographic and social data

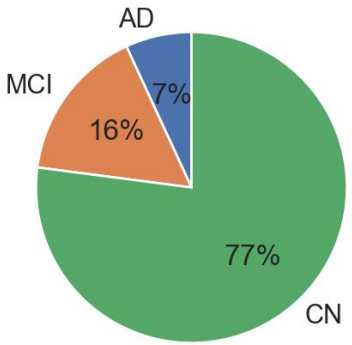
ADNI *(adni.loni.usc.edu)*

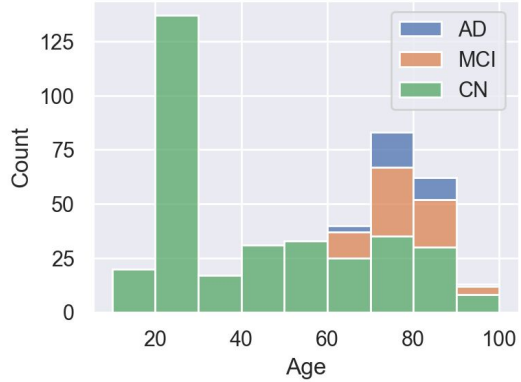
- 3D MRI images of 826 subjects
- Demographic and medical test results

	demographic				medical assessm.			cognitive tests				brain meas.		
	Sex	Age	Educ	Social	APOE	ABETA	…	MMSE	ADAS11	CDR	…	Ventr	Hippoc	…
OASIS	✓	✓	✓	✓	✘	✘	…	✓	✘	✓	…	✘	✘	…
ADNI	✓	✓	✓	✘	✓	✓	…	✓	✓	✓	…	✓	✓	…

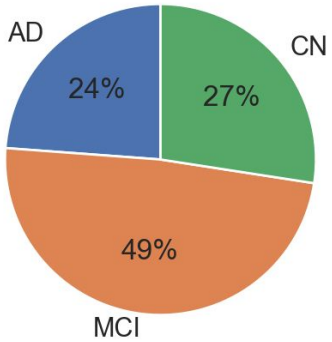
Overview of the data: demographic

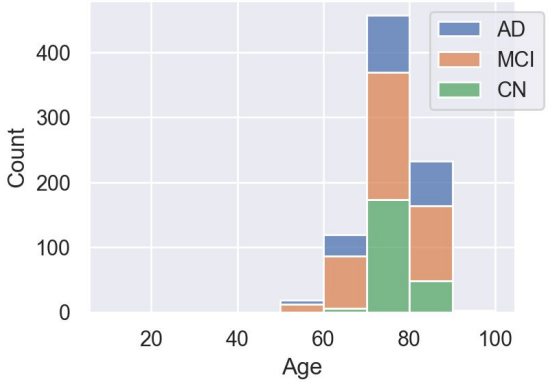
OASIS





ADNI





CN = cognitively normal

MCI = mild cognitive impairment

AD = Alzheimer's disease

Overview of the data: demographic

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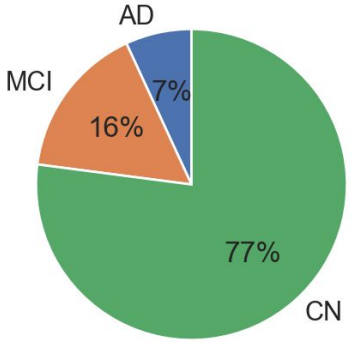
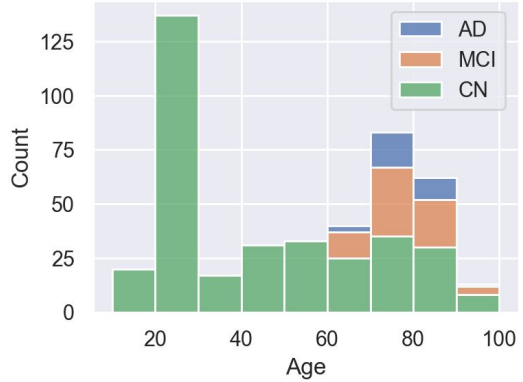
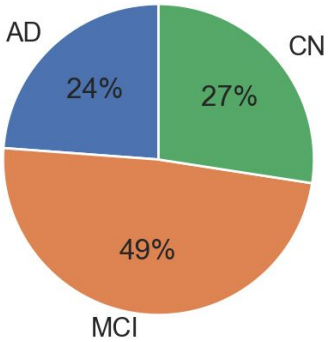
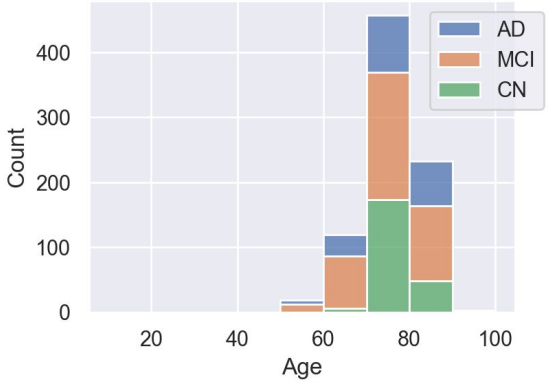


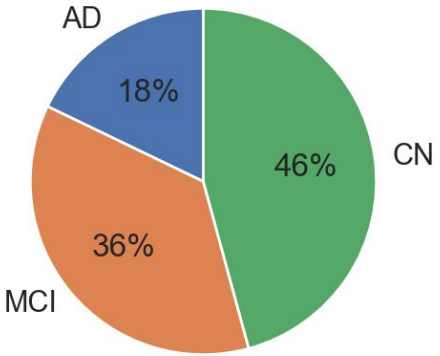


ADNI





Combined dataset



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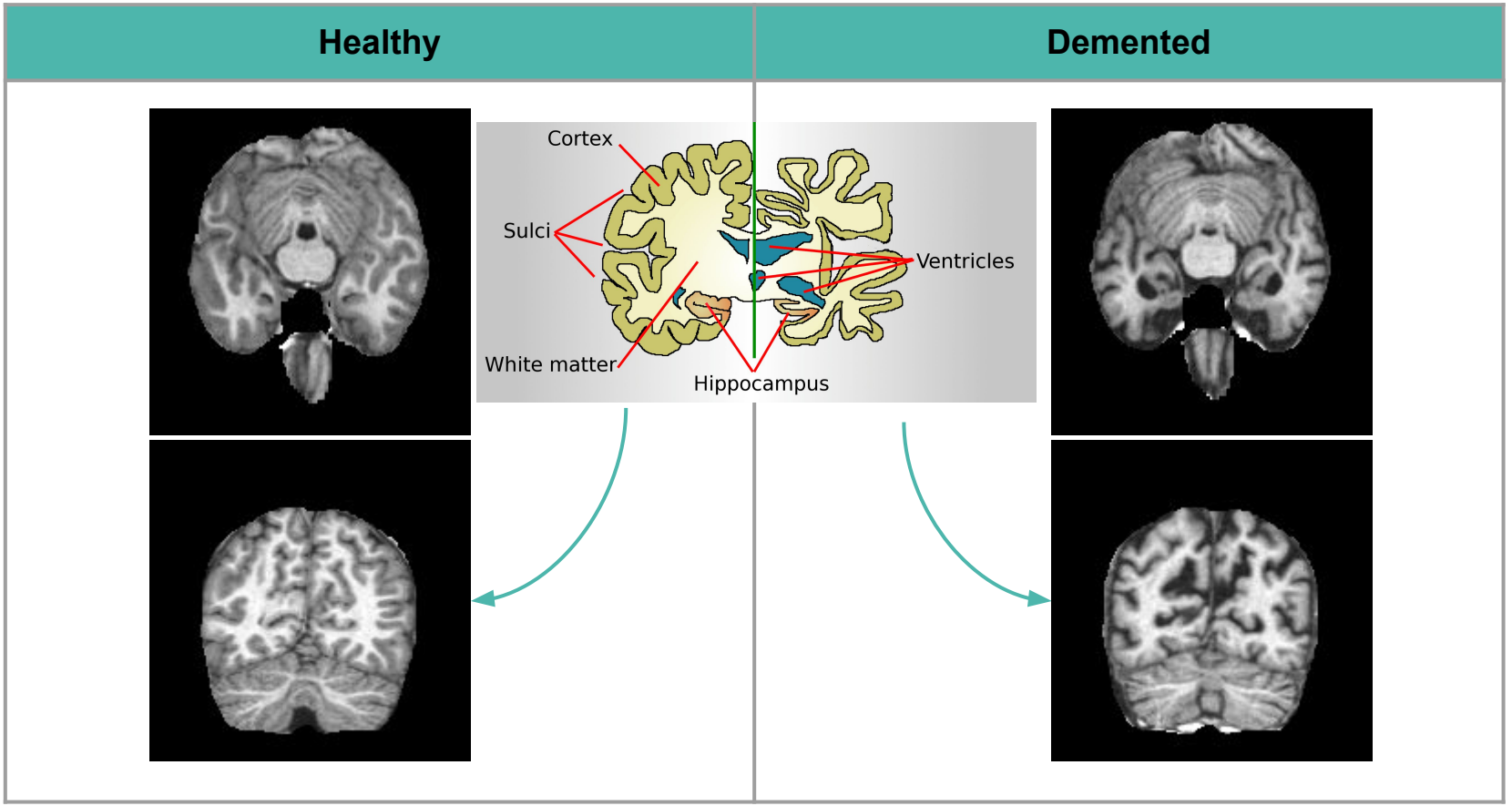
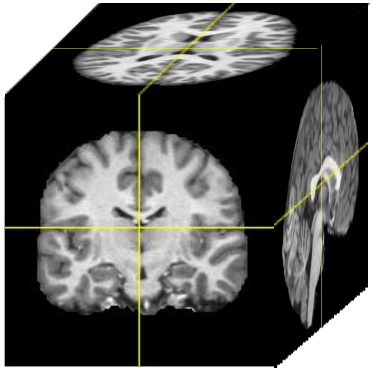
Images


Healthy
Demented
Cortex
Sulci
Ventricles
White matter
Hippocampus

Our Approach: Preprocessing

OASIS:

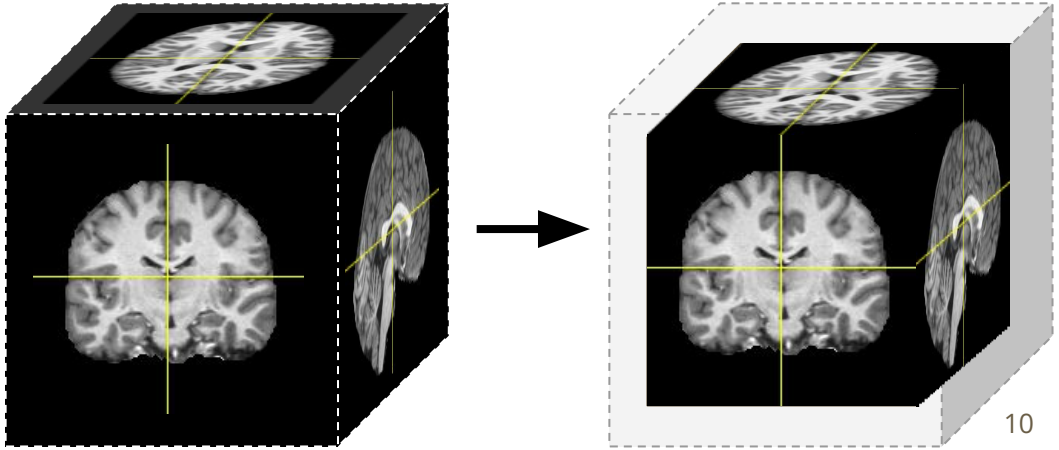
- already scaled to Atlas “standard brain” coordinates



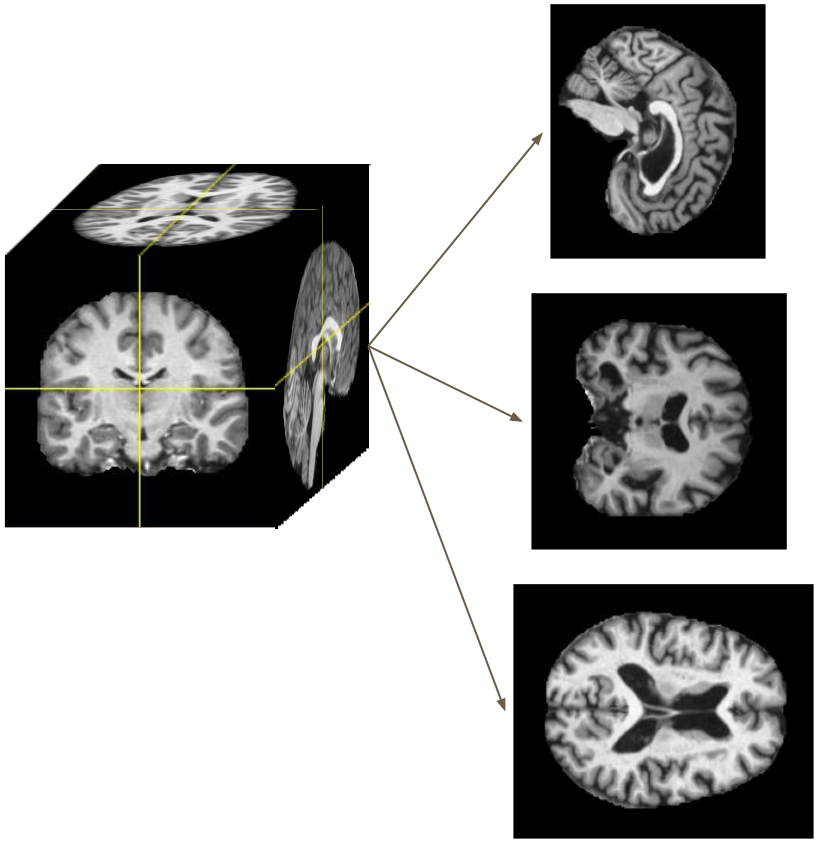
ADNI:

- centered to same locations as OASIS

- cropped to same dimensions



Preprocessing: Input selection



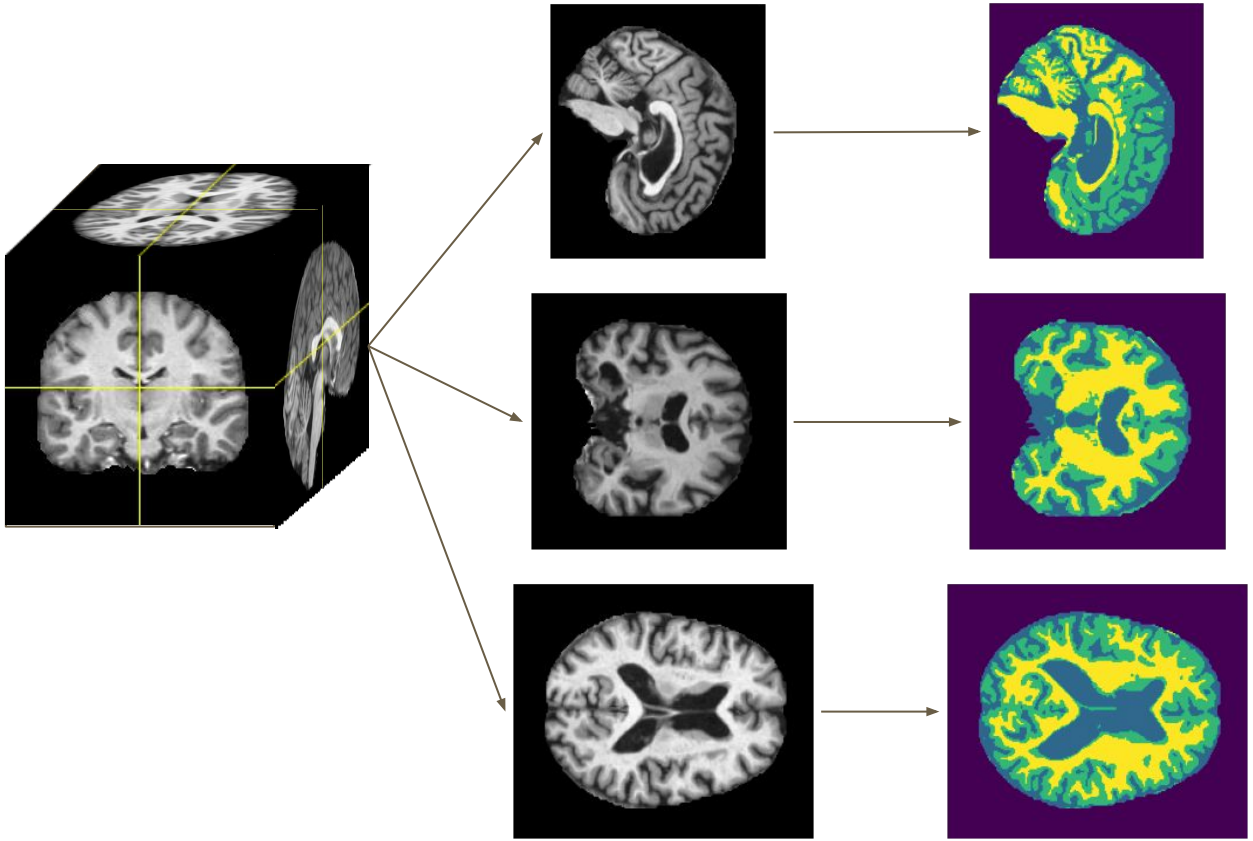
Find the best slice for each view that gives the most information

Our approach:

We searched for a specific slice number that gives the best result and used this slice for all images

(i.e. best slice is #90)

Preprocessing: Segmentation

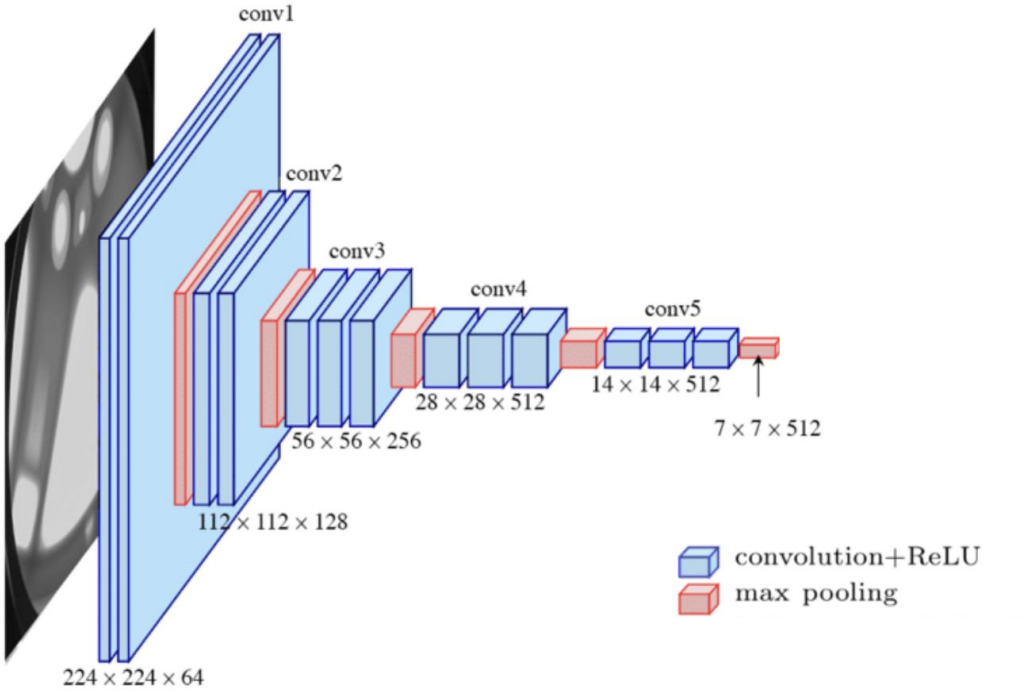


Segmentation of the brain tissues

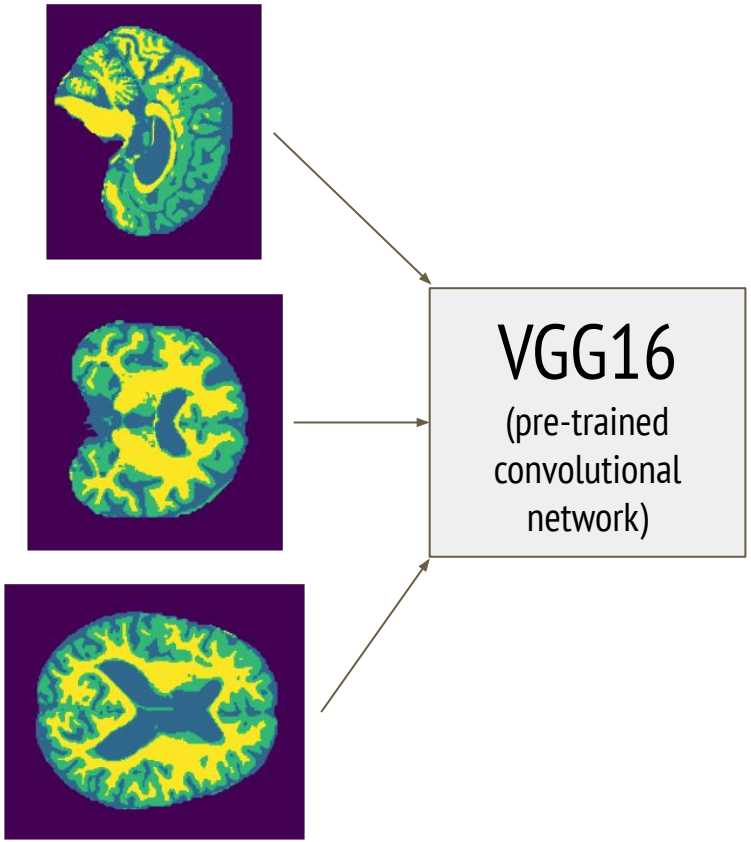
White Matter (WM): yellow
Gray Matter (GM): green
Cerebrospinal Fluid (CSF): blue

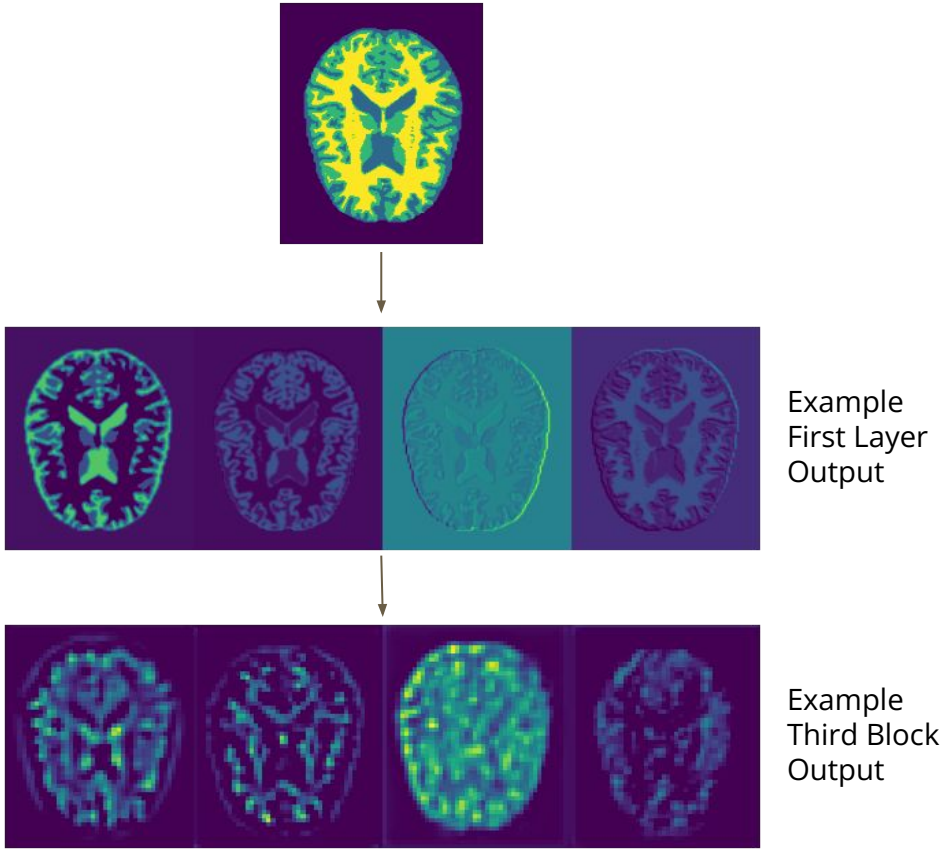
The modeling process

VGG16 is a convolutional neural network that is trained on more than a million images from the ImageNet database



The modeling process





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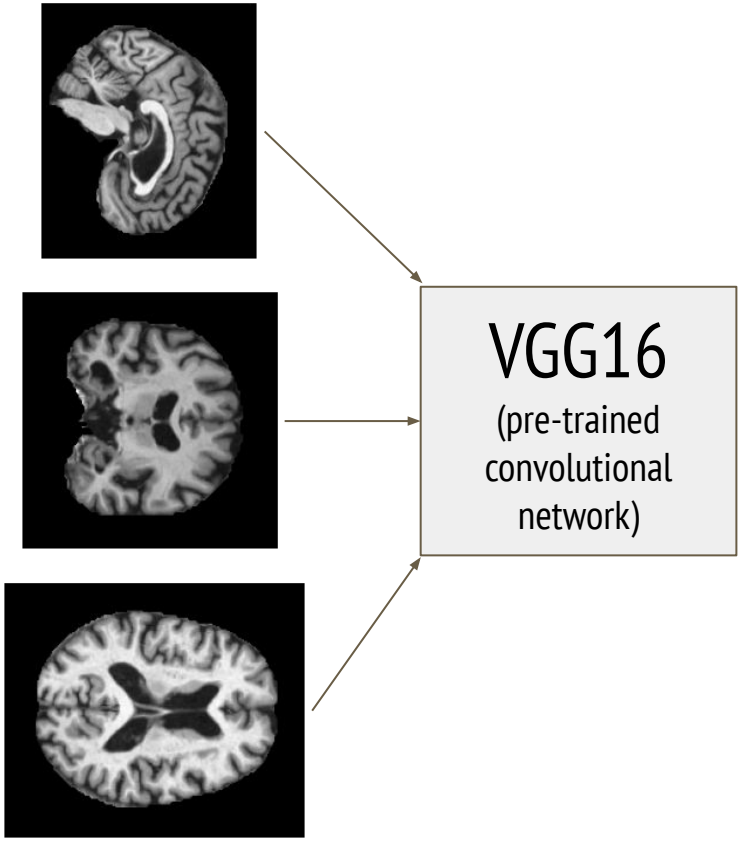

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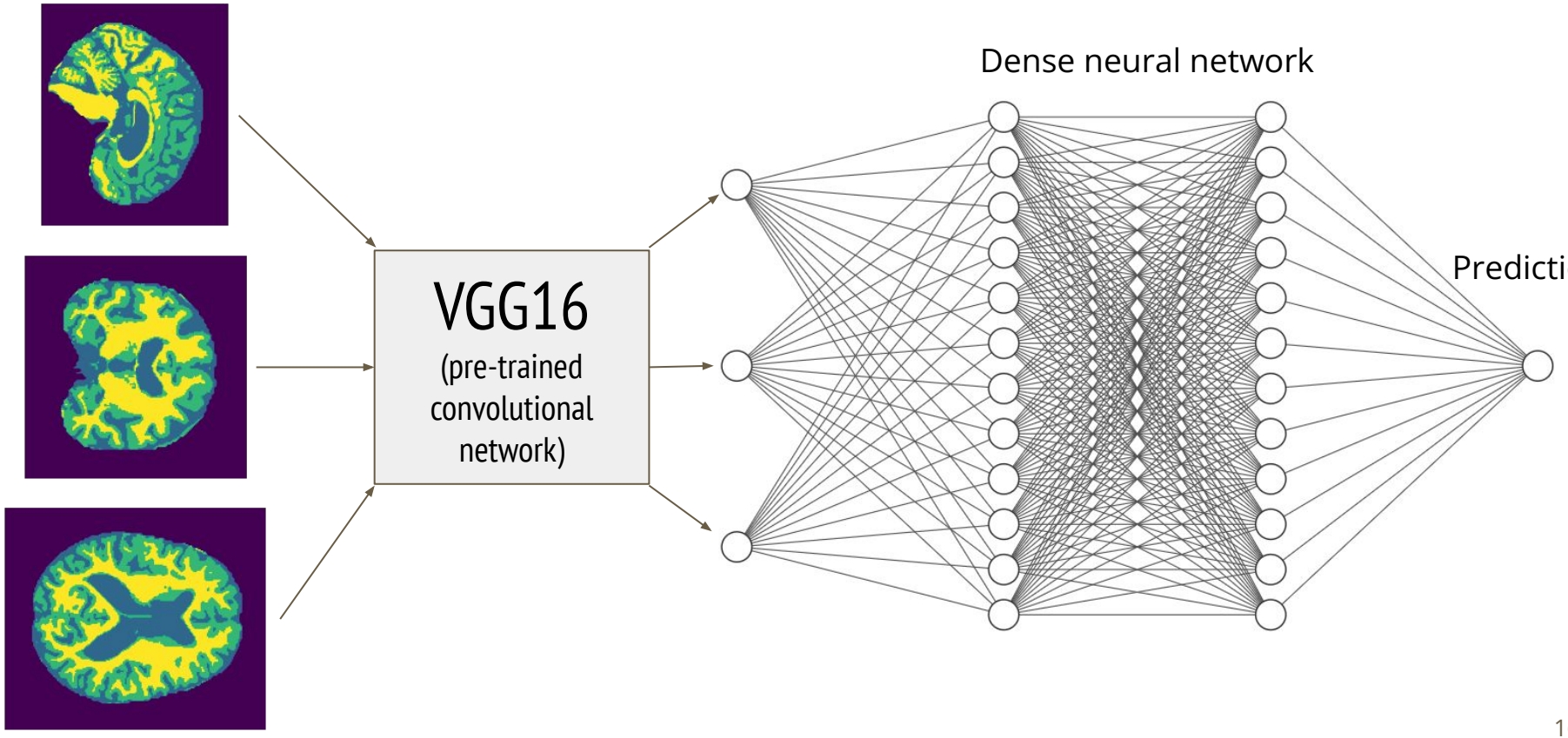
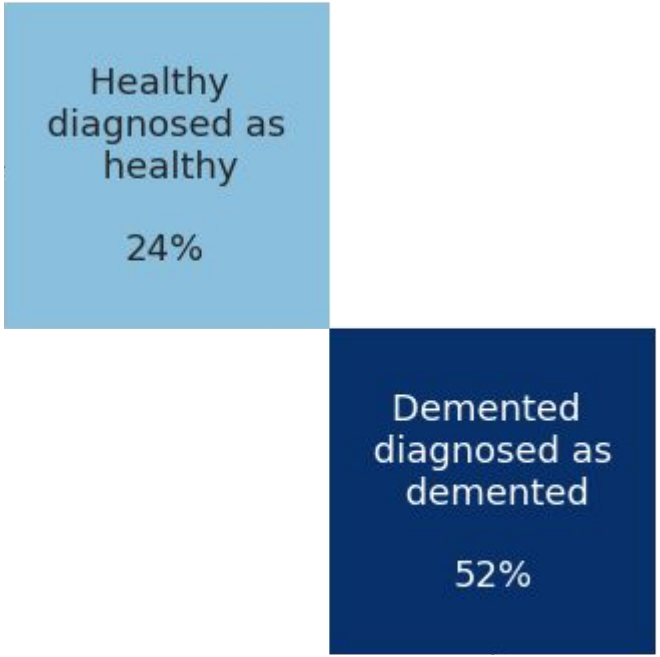


Modelling Results

Final model:

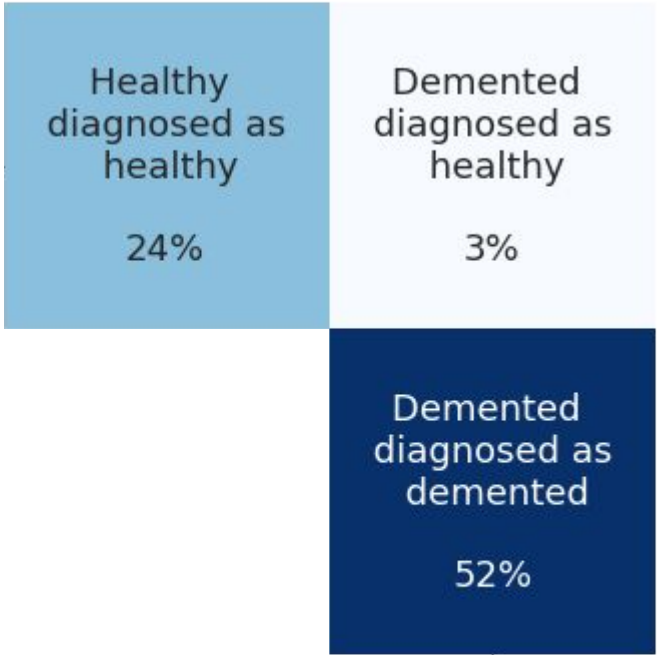
- Correct classification in 76% of cases



Modelling Results

Final model:

- Correct classification in 76% of cases
- Fraction of missed demented cases = 6%



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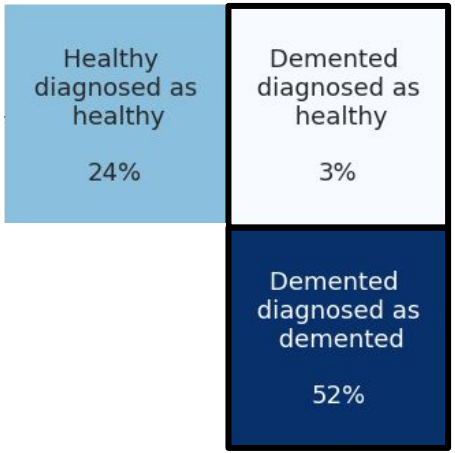
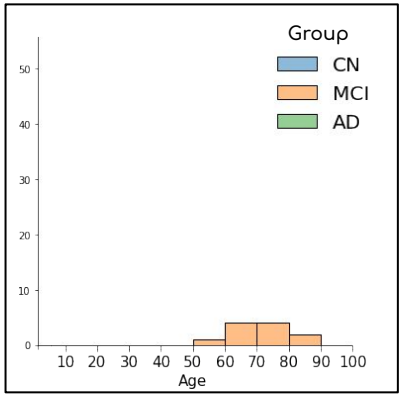
Error analysis:

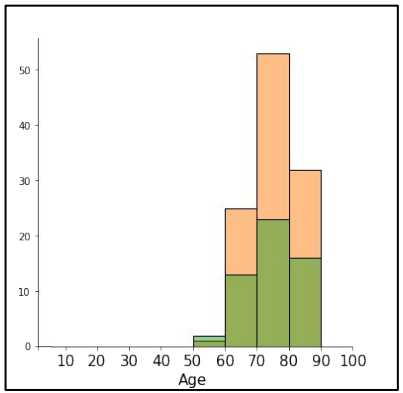
- undetected instances are all mild cases
  => MCI is very hard to detect



Missed Alzheimer cases



Detected Alzheimer cases



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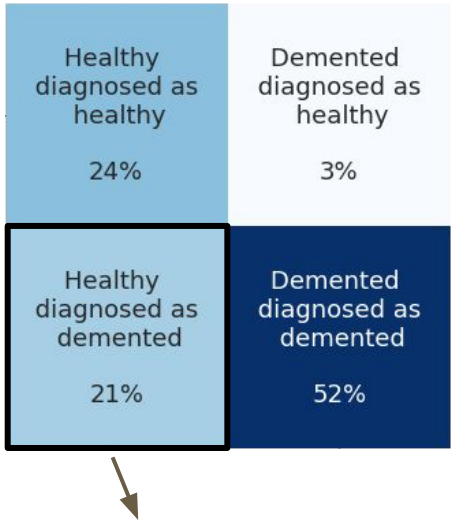
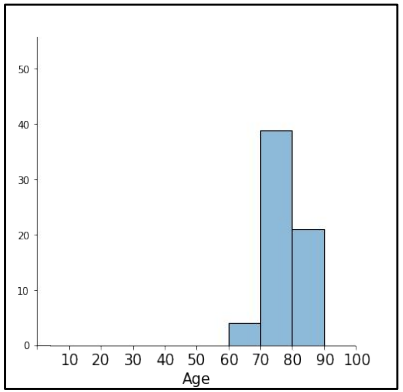


Misclassified healthy cases



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- undetected instances are all mild cases
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- age related degeneration
  => older healthy brains misclassified

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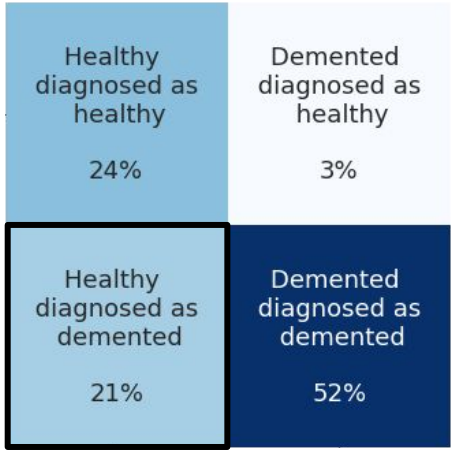

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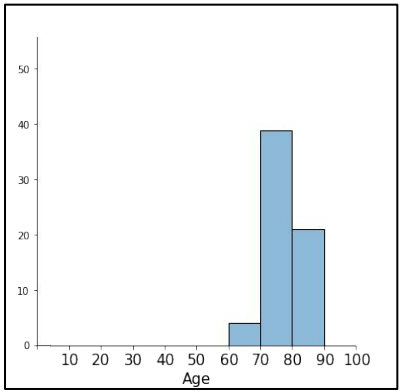

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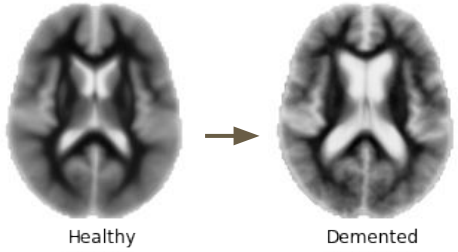
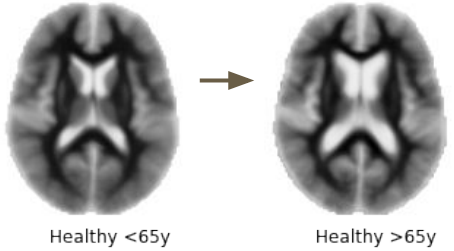
Alzheimer's degeneration

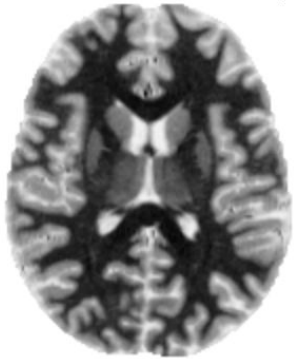


Age related degeneration



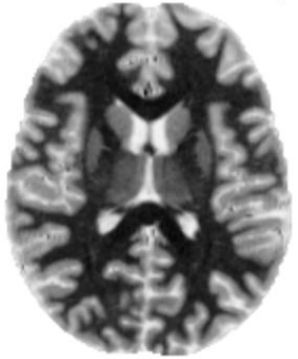
#1 reason for misdiagnosis by professionals

Summary



- robust model trained on high-variance data
- works well with only three 2D slices
- 4% increase in accuracy
- Fraction of missed MCI/AD cases decreased by 21%

Summary



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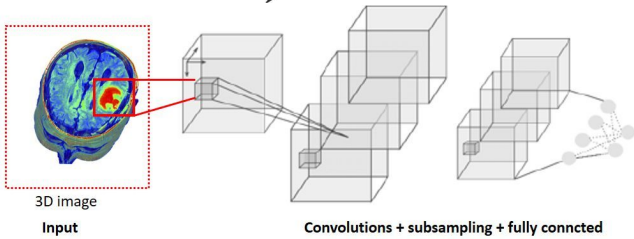
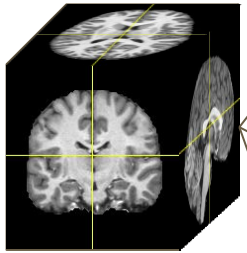
Outlook

- Harness the power of the cloud

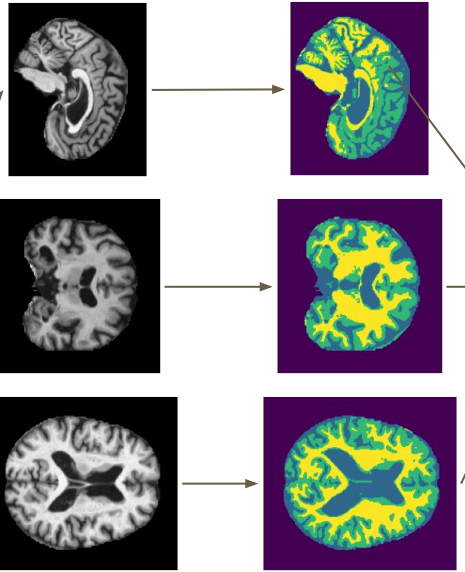
  => develop 3D convolutional network

  => automated Atlas correction
  and denoising

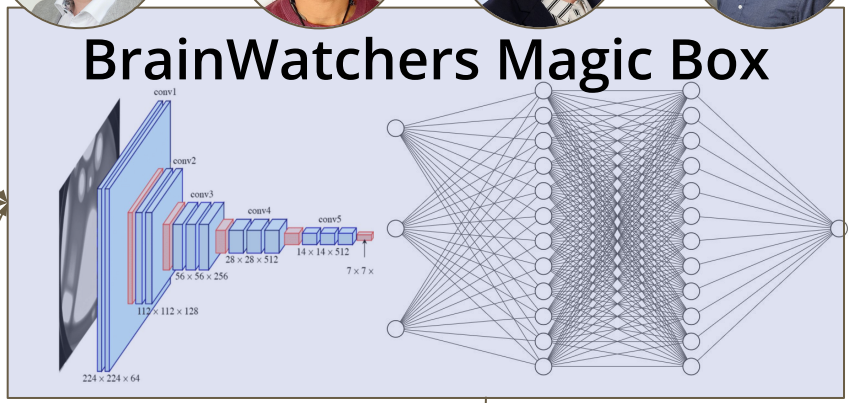




3D MRI Images



Get slices and image segmentation



Healthy diagnosed as healthy 24%	Demented diagnosed as healthy 3%
Healthy diagnosed as demented 21%	Demented diagnosed as demented 52%