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Medical image segmentation for clinical application

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Preprocessing

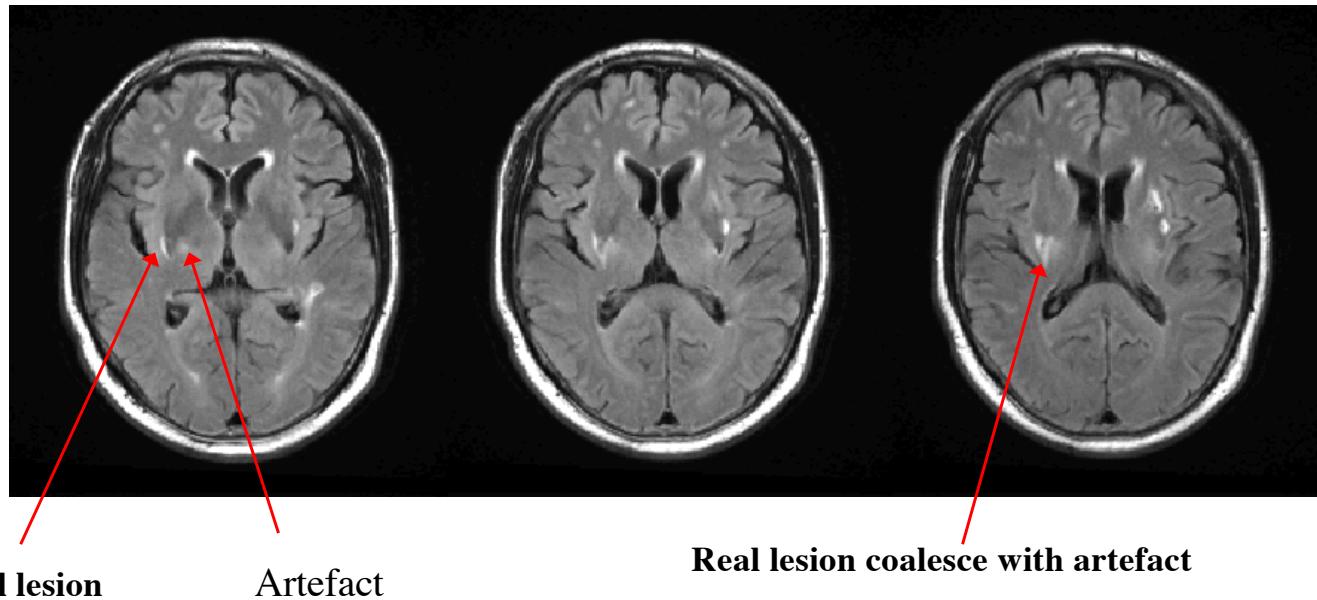
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Imaging artefacts

Imaging artefacts

- Effects which appear in the reconstructed images and are not present in the true anatomy
- They can lead to misdiagnosis if not adequately identified

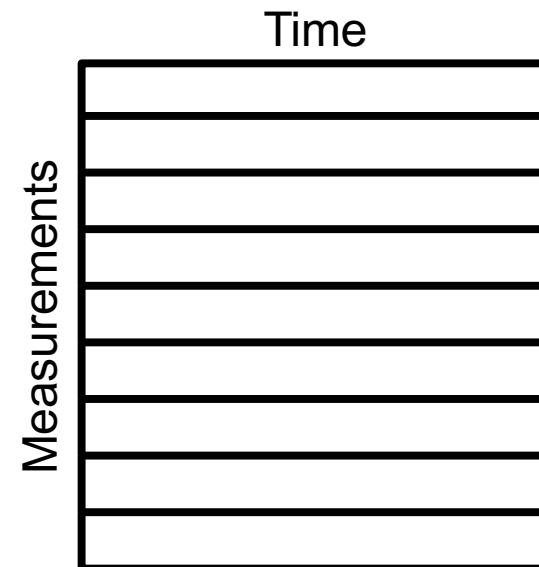
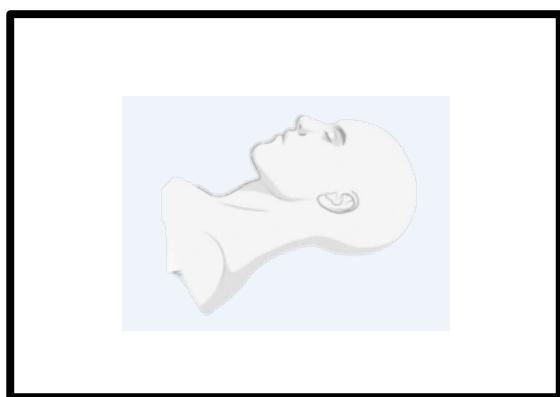


Categories of imaging artefacts

- Motion artefacts
- Partial volume
- Reconstruction artefacts
- Magnetic field artefacts
- RF artefacts
- Noise

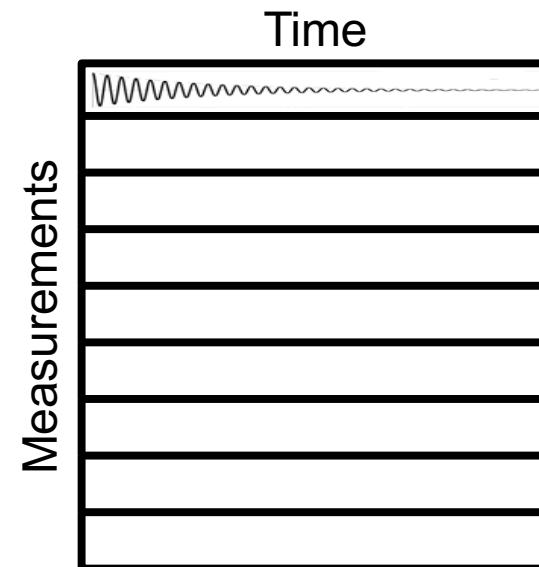
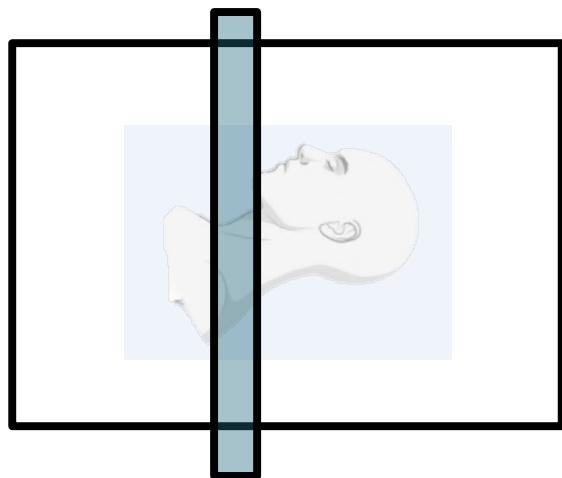
Motion artefacts

- Inconsistencies in image acquisition



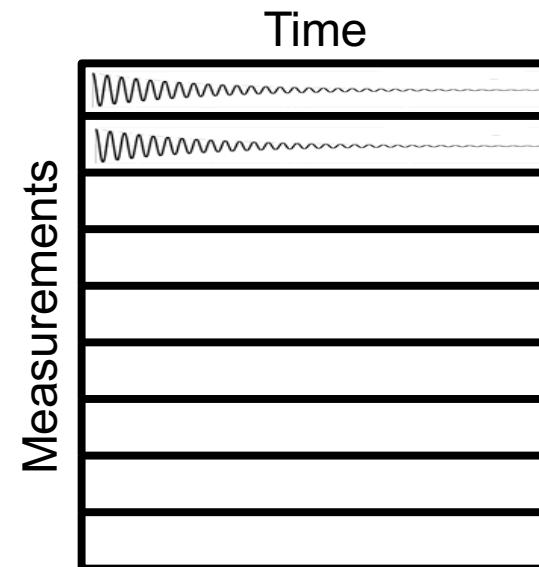
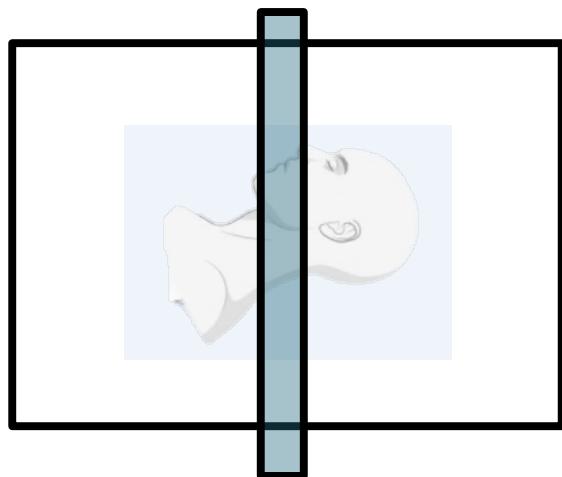
Motion artefacts

- Inconsistencies in image acquisition



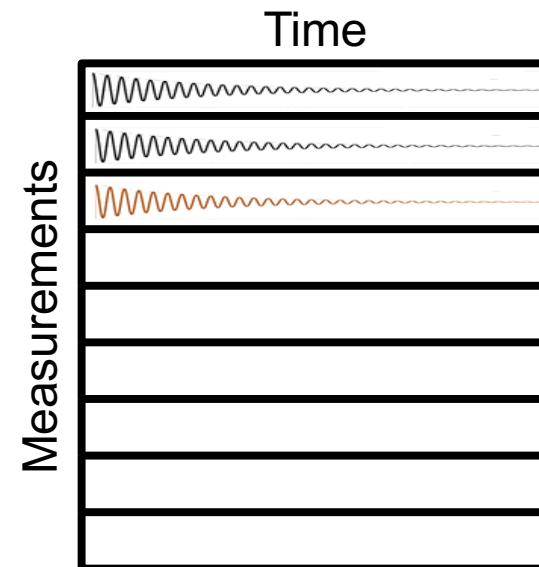
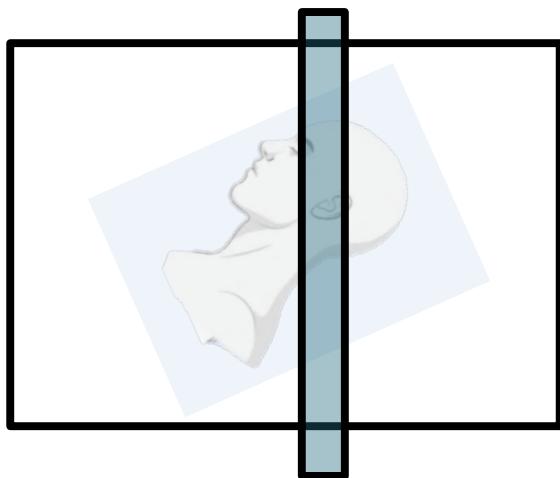
Motion artefacts

- Inconsistencies in image acquisition



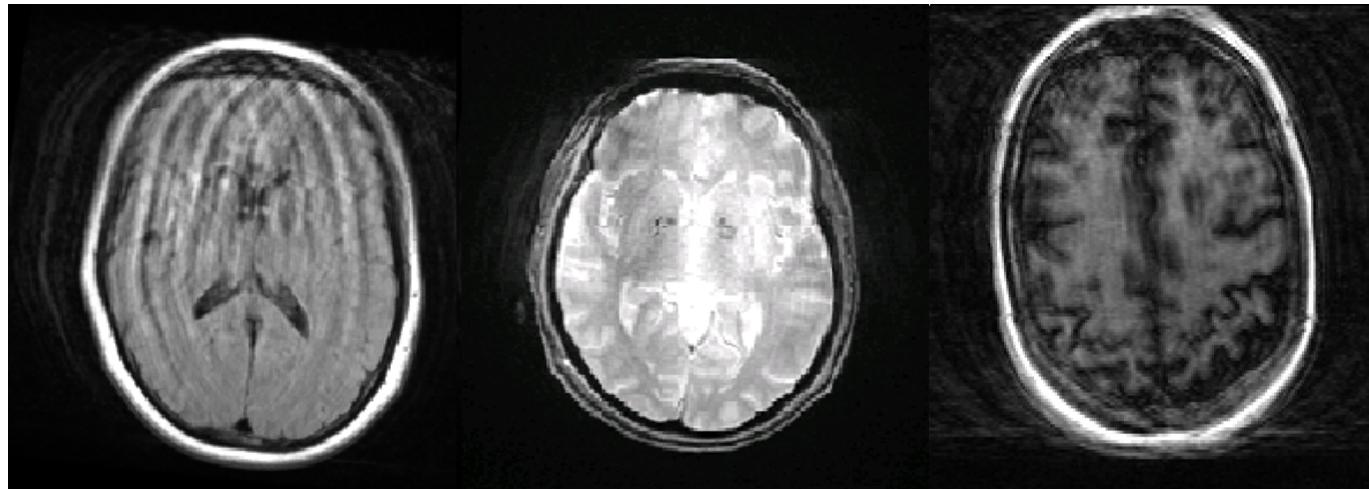
Motion artefacts

- Inconsistencies in image acquisition



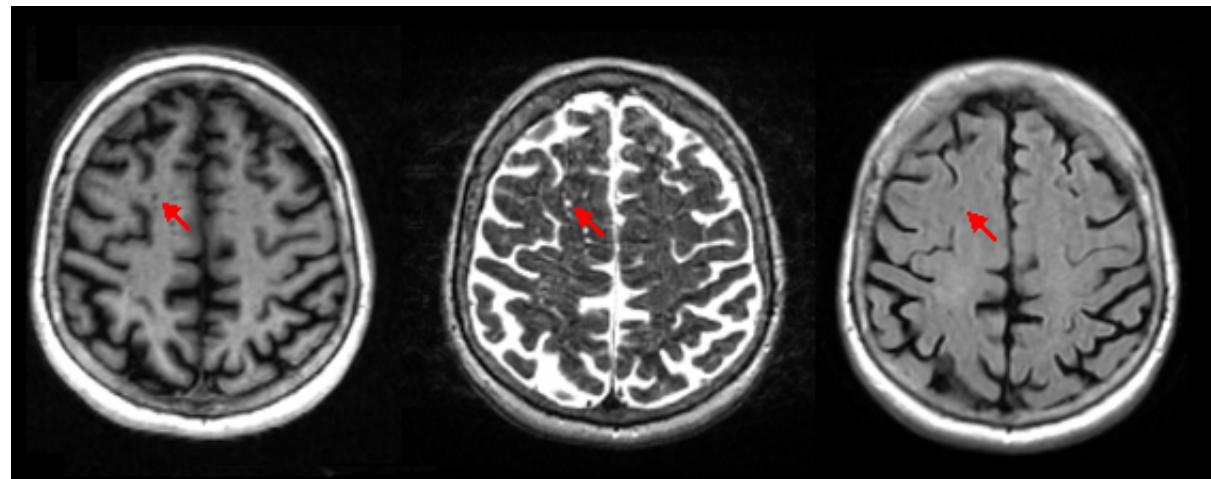
Motion artefacts

- Inconsistencies in image acquisition, leading to blurring and ghosting



Partial volume effect

- Caused by slice thickness



T1-weighted

(2 mm thick)

T2-weighted

(2 mm thick)

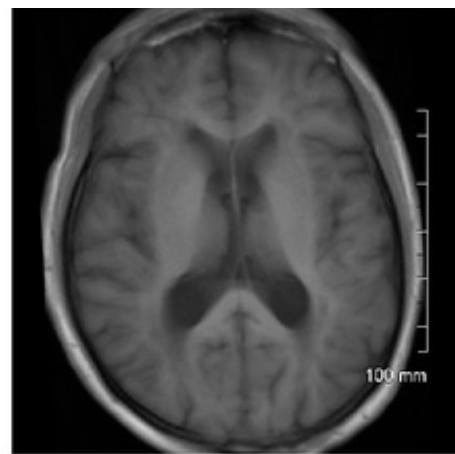
FLAIR

(4 mm thick)

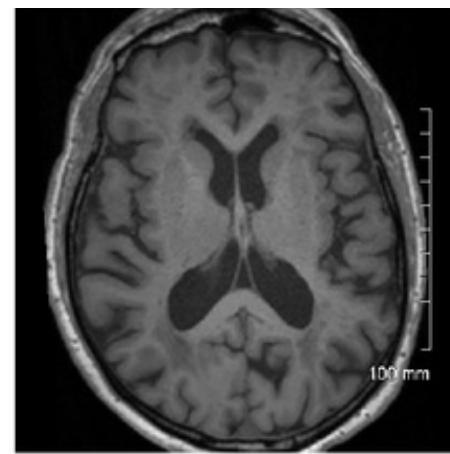
Partial volume effect

- Caused by slice thickness

20 mm thickness



2 mm thickness



Truncation artefacts

- Too little measurements of the object of interest

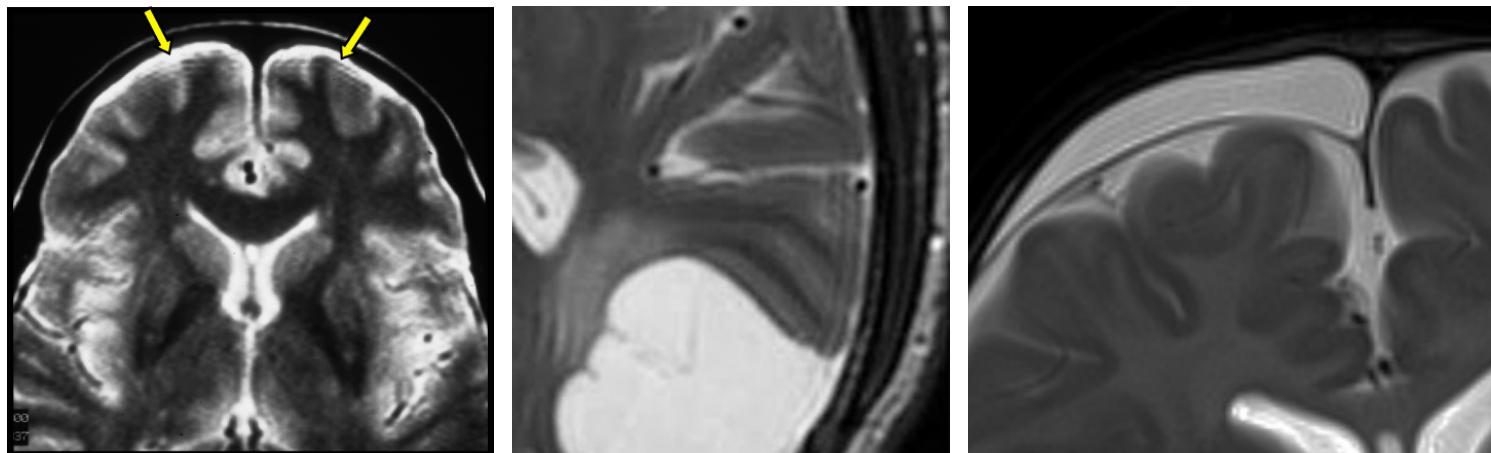


Image credits: <http://mriquestions.com/gibbs-artifact.html>

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Magnetic field inhomogeneity

- Field inhomogeneities are cause by environmental factors, improper shimming and the use of short bore magnets

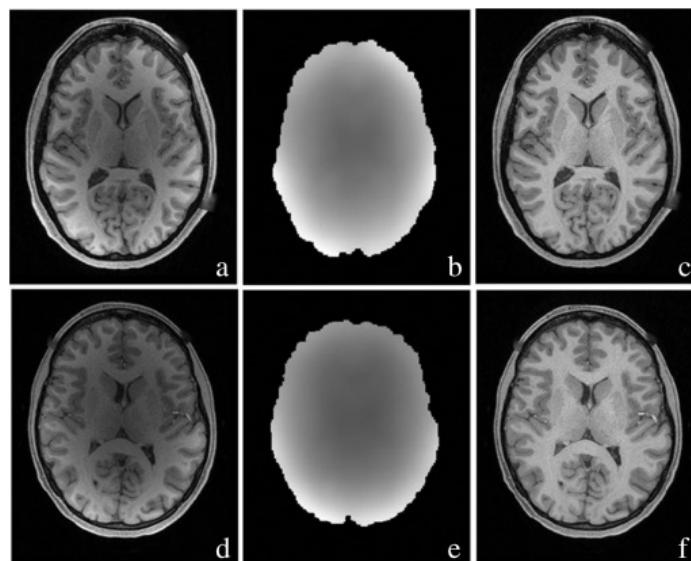


Image credits: <https://www.sciencedirect.com/science/article/pii/S0730725X17301005>

Noise

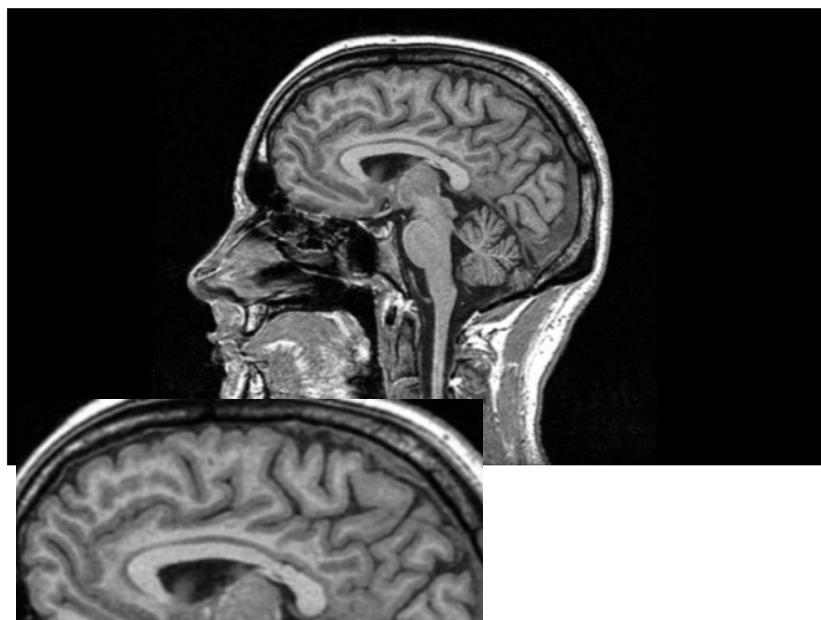
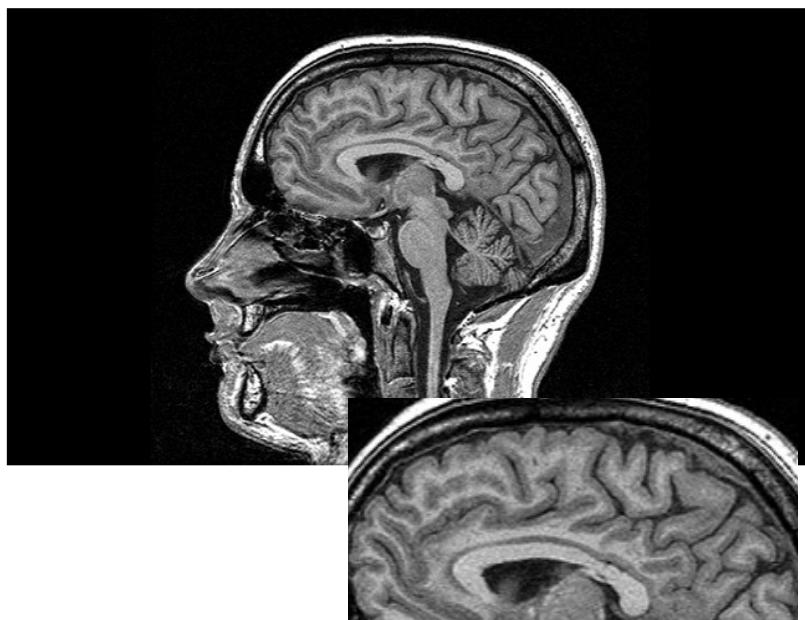


Image preprocessing

Image

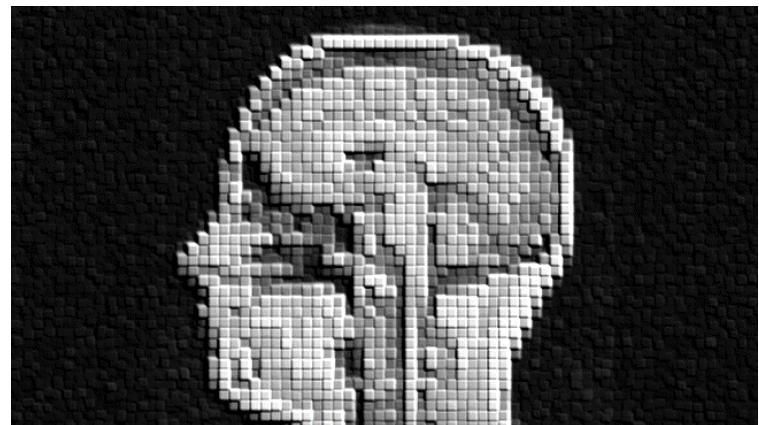
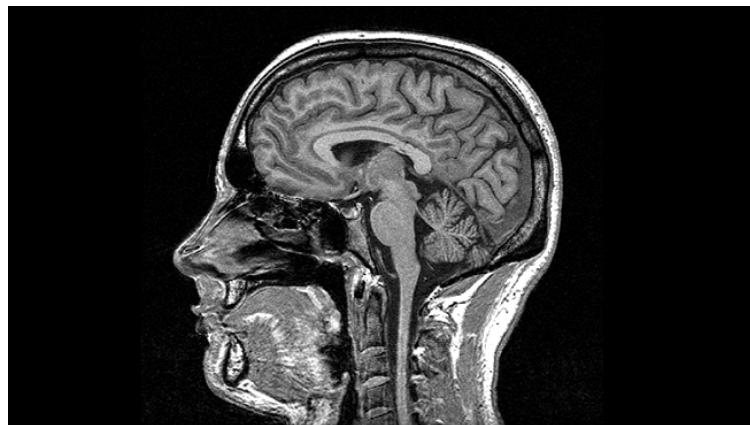


Image preprocessing

- Image enhancement

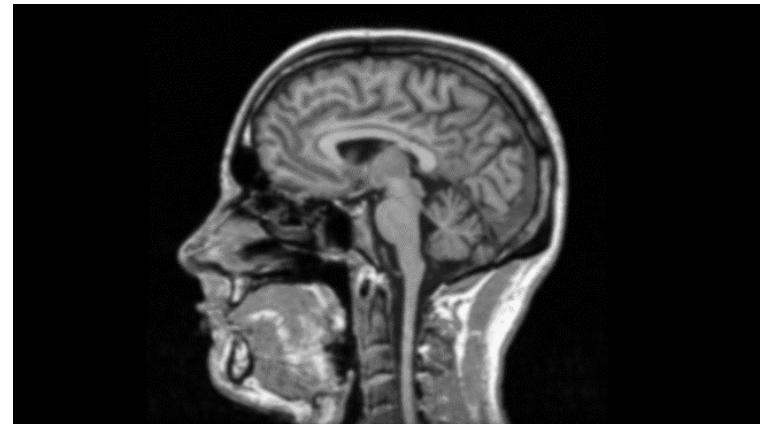


Image preprocessing

- Image enhancement

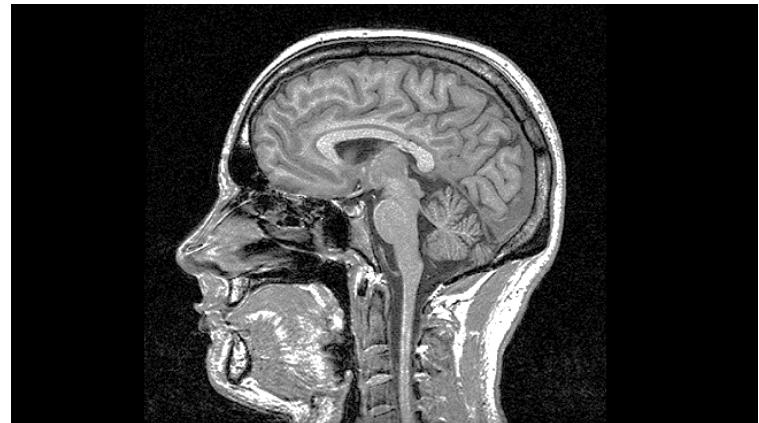
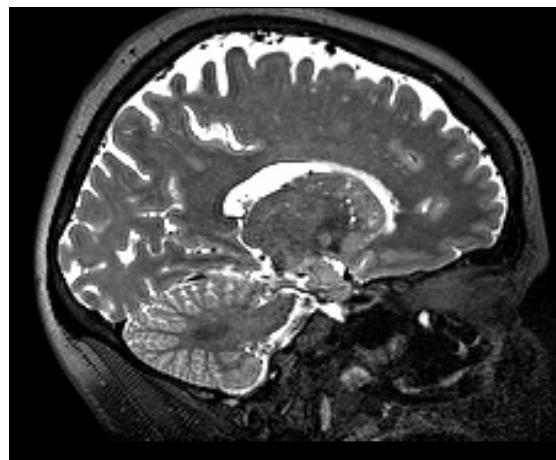


Image preprocessing

- Image enhancement

“Clean” T2-w scan



Segmented PVS

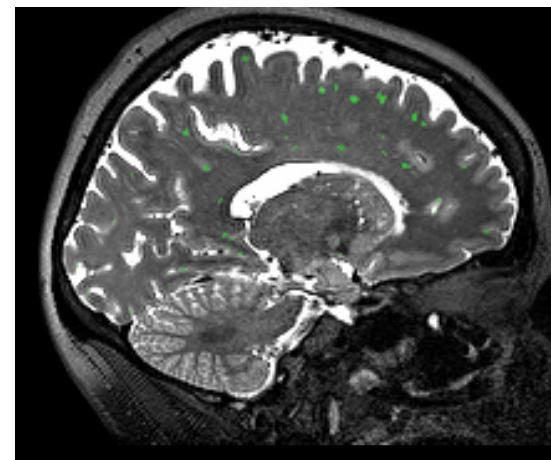
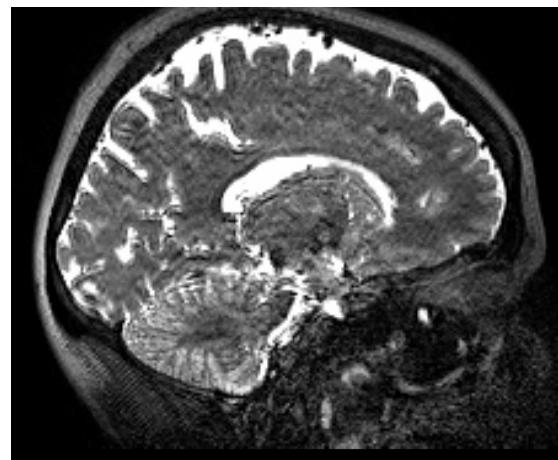


Image preprocessing

- Image enhancement

“Noisy” T2-w scan



Segmented PVS

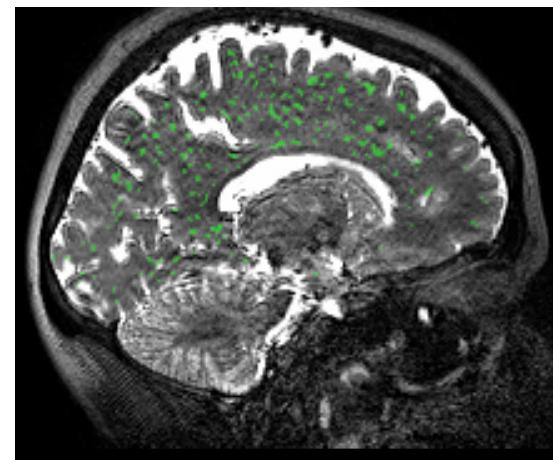
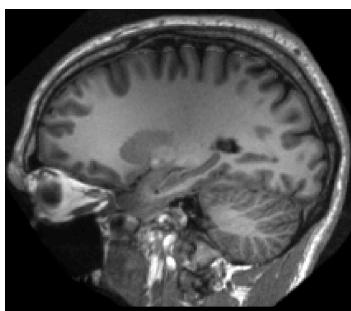


Image preprocessing

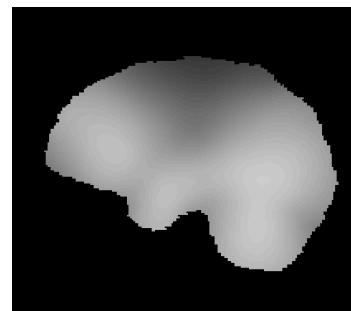
- Correction of intensity inhomogeneity



Original T1-w



Skull-stripped



Bias field



Pre-processed

Image preprocessing

- Reduction of uninteresting inter-subject inter-scan variability

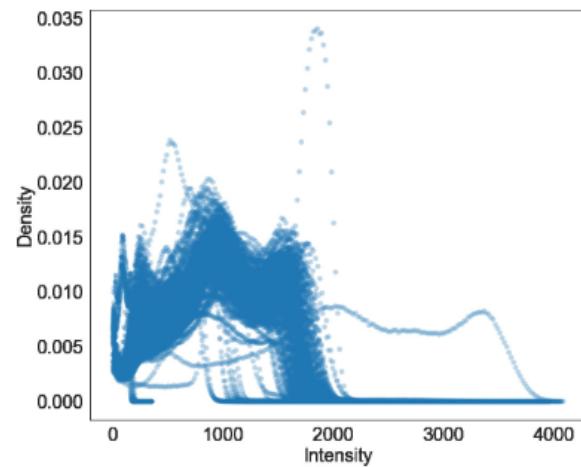


Image preprocessing

- Reduction of uninteresting inter-subject inter-scan variability

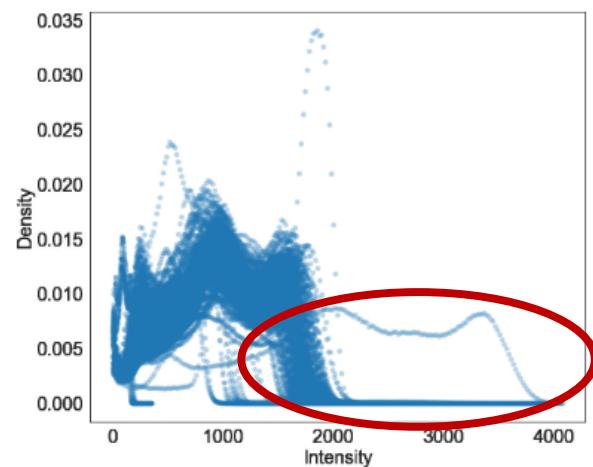


Image preprocessing

- Reduction of uninteresting inter-subject inter-scan variability

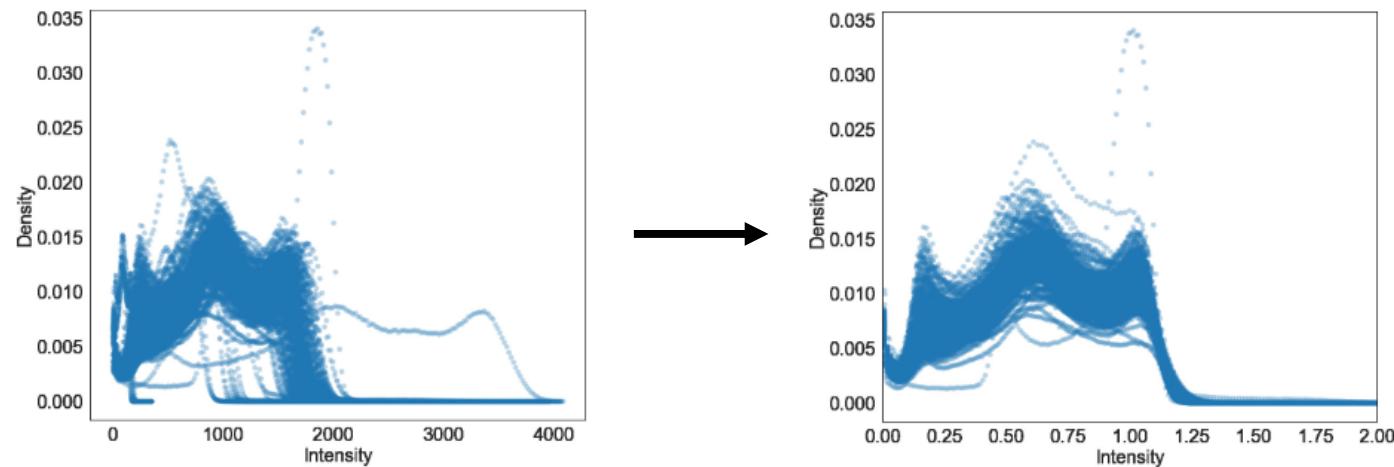
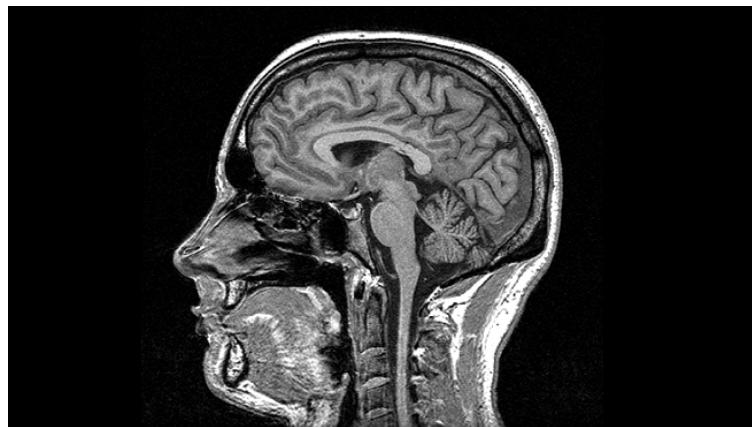


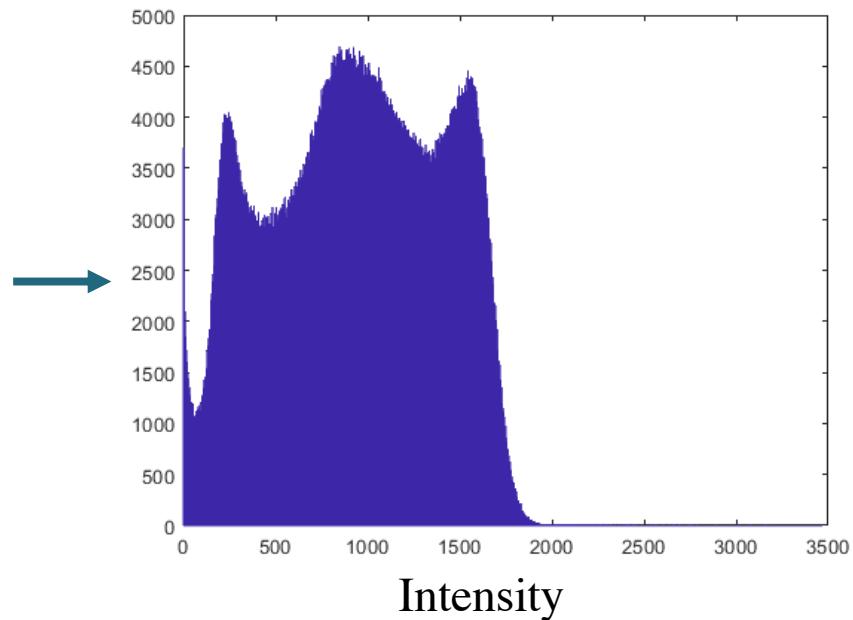
Image preprocessing

- Intensity standardisation
- Denoising

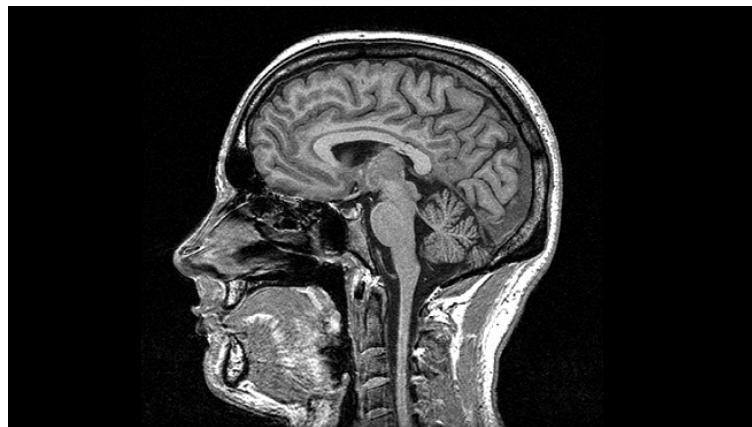
Histogram of intensities



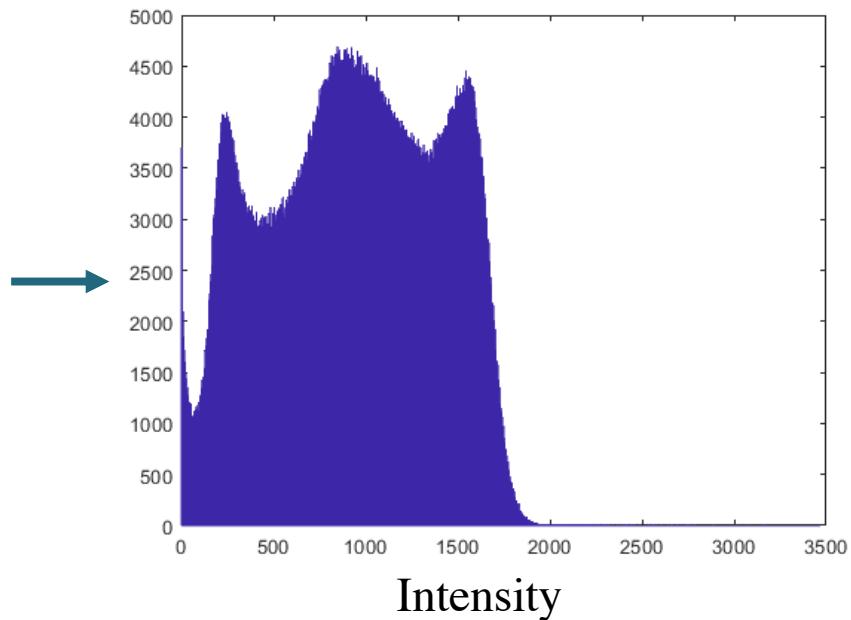
Frequency



Histogram of intensities



Frequency



Intensity standardisation

- Removed unwanted intensity variations

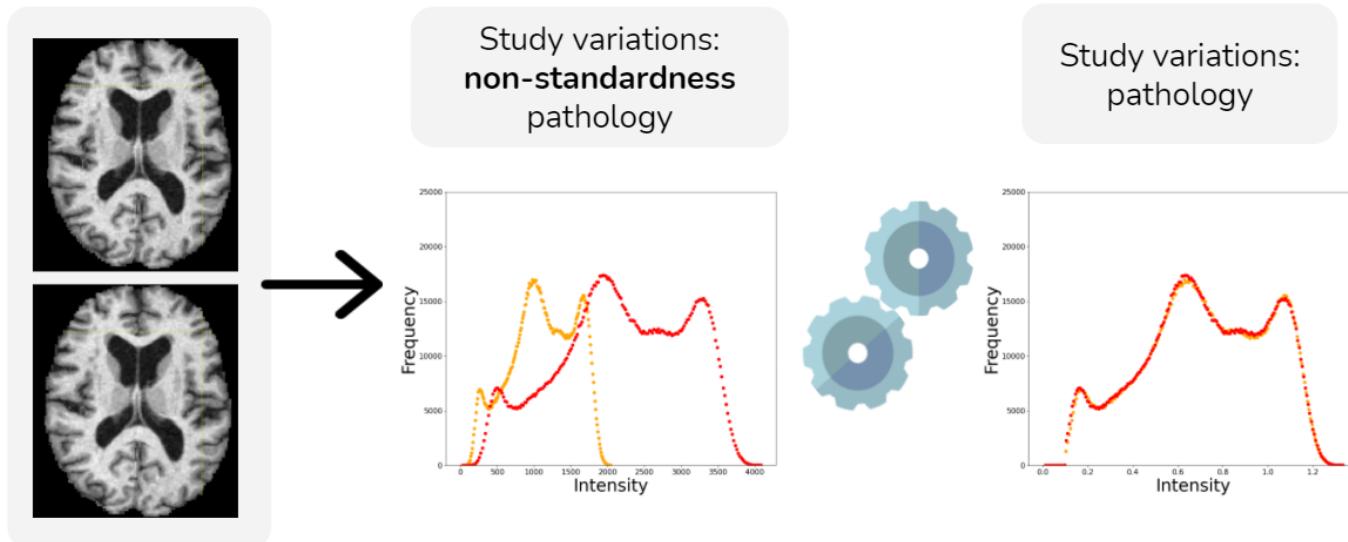


Image credits: Emily Carvajal

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Intensity standardisation

- Transform intensities to make tissue modes coincide

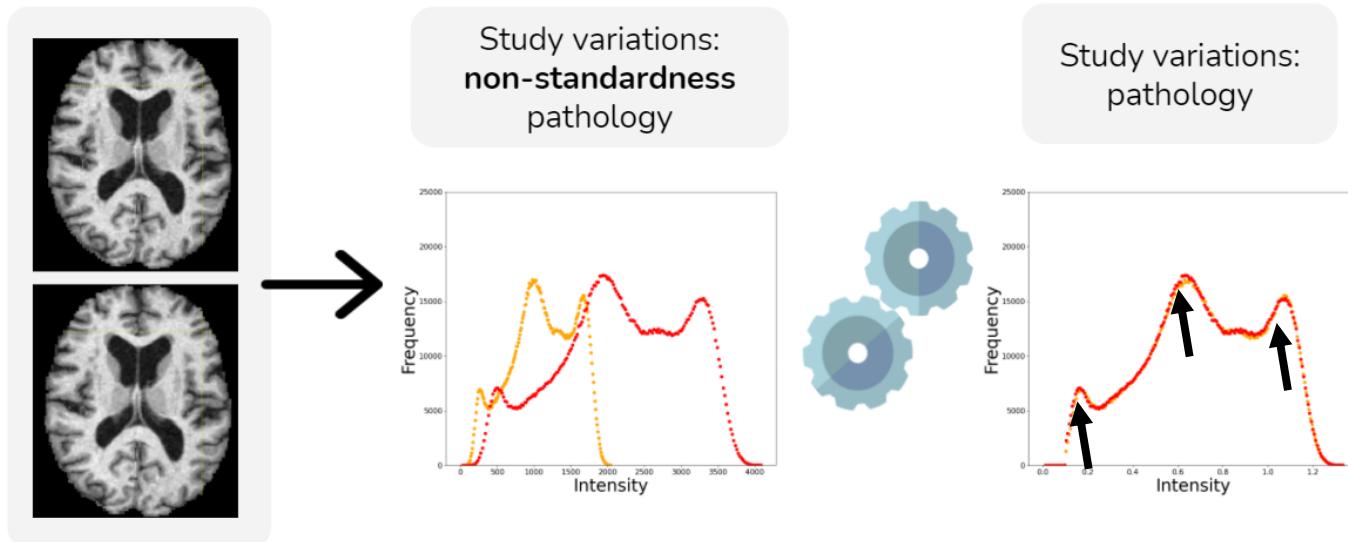
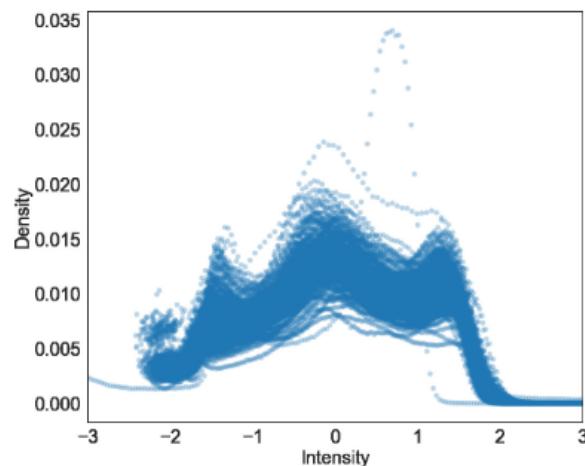
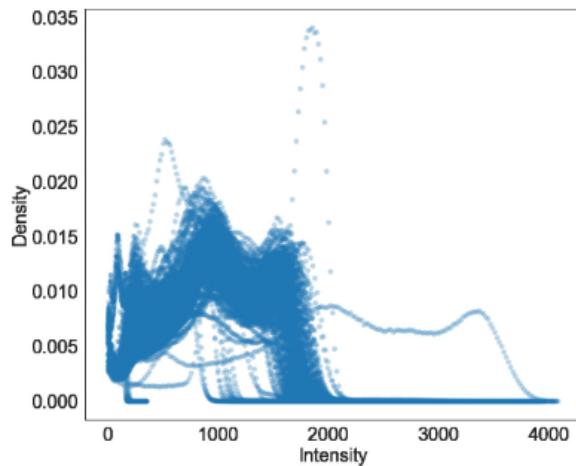


Image credits: Emily Carvajal

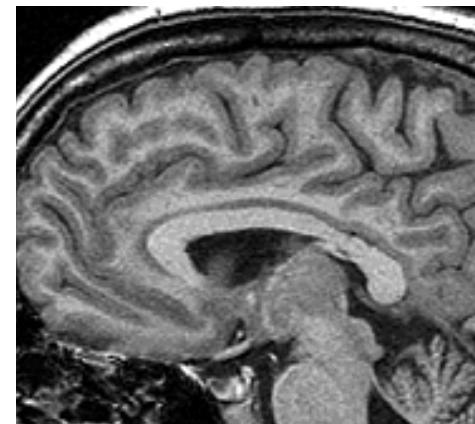
30

Intensity standardisation

- z-score transformation
 - Compute mean intensity μ and standard deviation σ
 - Subtract μ from all intensities and divide by standard deviation

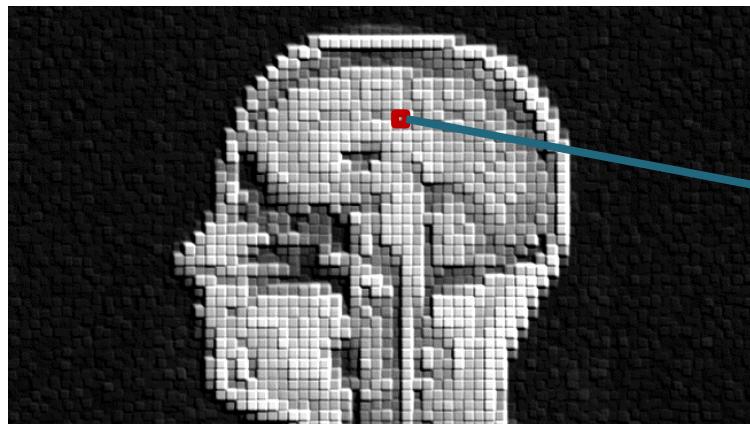


Denoising



Mean filter

- For each voxel, replace its value by mean intensity in its *neighbourhood*



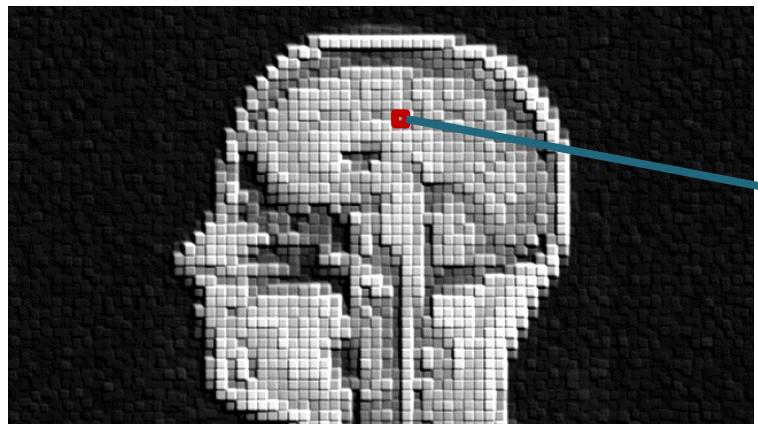
Original values				
20	30	20	23	31
20	25	30	25	20
30	20	90	20	22
25	28	24	26	20
50	12	26	21	23

Filtered values				
		37		

$$\text{mean}(30+20+90+20+24)$$

Mean filter

- For each voxel, replace its value by mean intensity in its *neighbourhood*



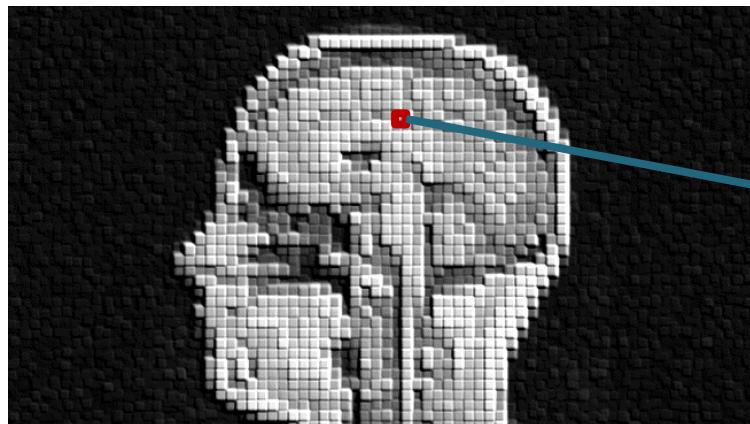
Original values				
20	30	20	23	31
20	25	30	25	20
30	20	90	20	22
25	28	24	26	20
50	12	26	21	23

Filtered values				
		37	36	

$$\text{mean}(25+90+22+20+26)$$

Mean filter

- For each voxel, replace its value by mean intensity in its *neighbourhood*



Original values

20	30	20	23	31
20	25	30	25	20
30	20	90	20	22
25	28	24	26	20
50	12	26	21	23

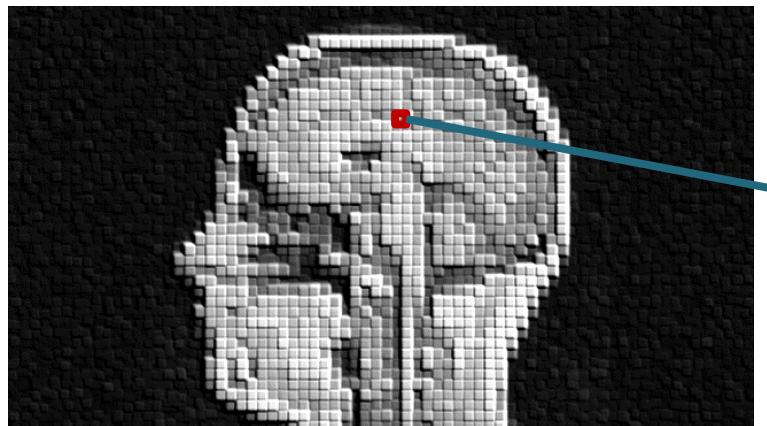
Filtered values

23				

$$\text{mean}(20+20+30)$$

Mean filter

- For each voxel, replace its value by mean intensity in its *neighbourhood*



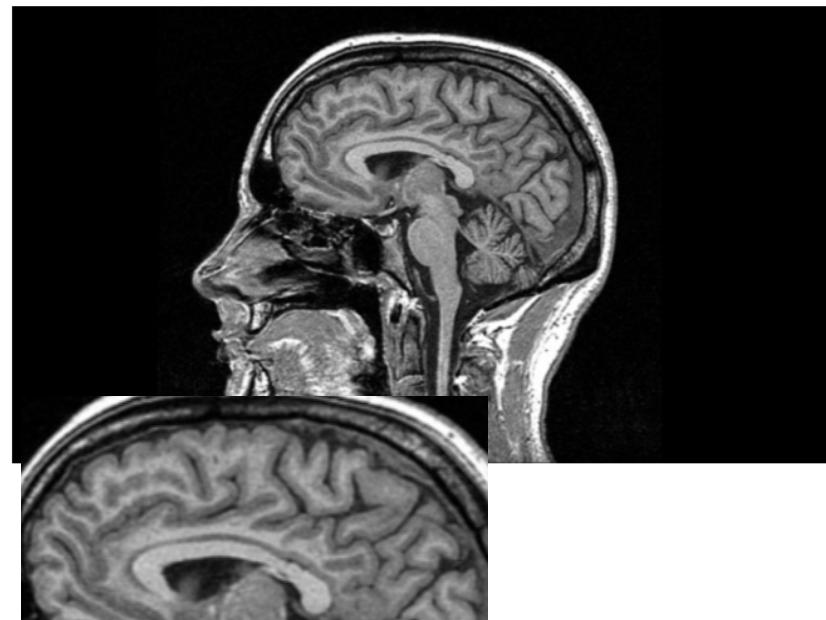
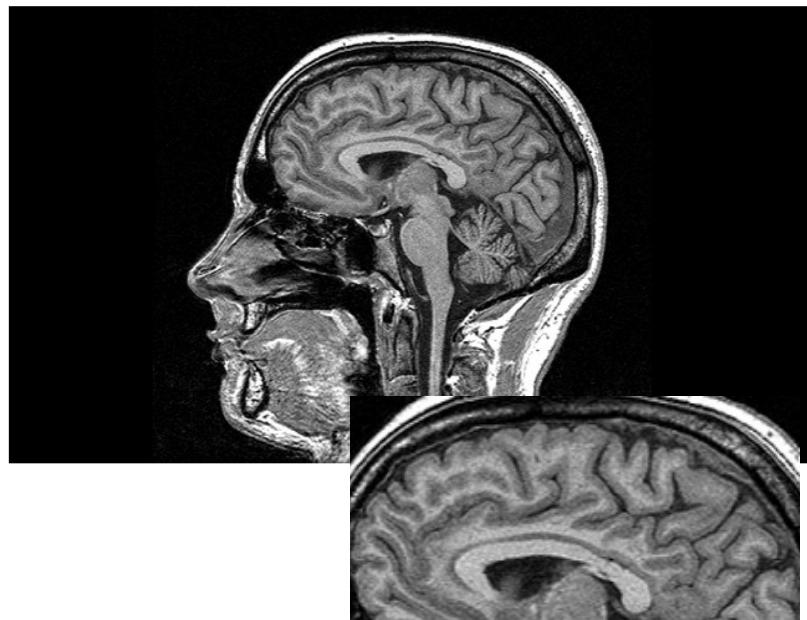
Original values

20	30	20	23	31
20	25	30	25	20
30	20	90	20	22
25	28	24	26	20
50	12	26	21	23

Filtered values

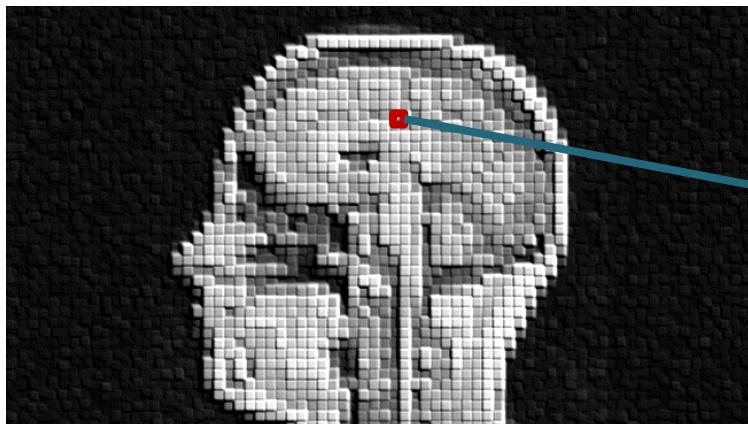
23	24	26	25	25
24	25	38	24	25
24	39	37	36	21
32	22	39	22	23
29	29	21	24	21

Mean filter



Mean filter

- What if the *neighbourhood* is larger?



Original values

20	30	20	23	31
20	25	30	25	20
30	20	90	20	22
25	28	24	26	20
50	12	26	21	23

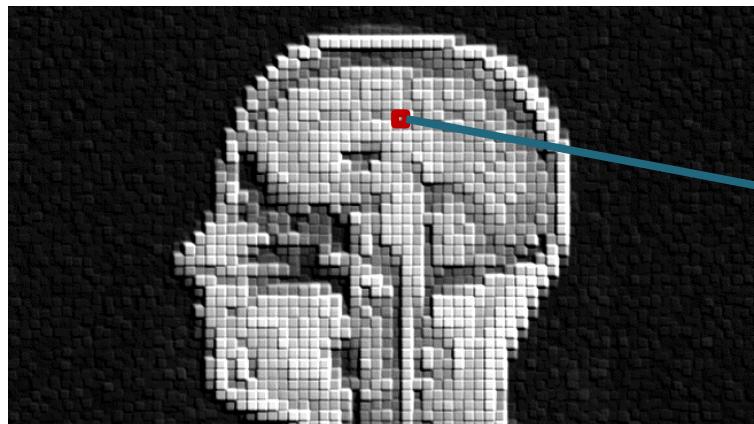
Filtered values

		37		

$$\text{mean}(30+20+90+20+24)$$

Mean filter

- What if the *neighbourhood* is larger?



Original values

20	30	20	23	31
20	25	30	25	20
30	20	90	20	22
25	28	24	26	20
50	12	26	21	23

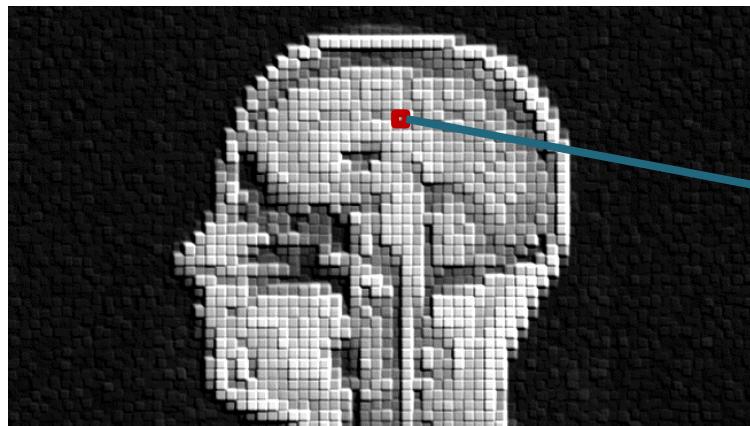
Filtered values

		32		

$$\text{mean}(25+30+25+20+90+20+28+24+26)$$

Mean filter

- What if the *neighbourhood* is larger?



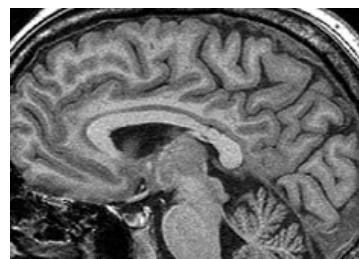
Original values				
20	30	20	23	31
20	25	30	25	20
30	20	90	20	22
25	28	24	26	20
50	12	26	21	23

Filtered values				
		27		

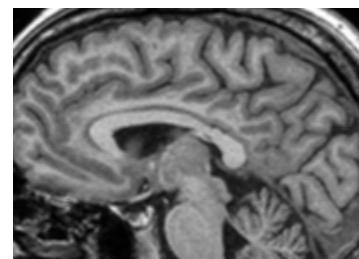
$$\text{mean}(20+30+20+23+31+20+25+30+25+20+30+20+90+20+22+25+28+24+26+20+50+12+26+21+23)$$

Mean filter

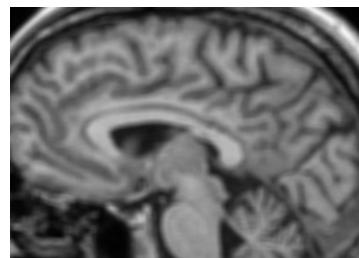
Original



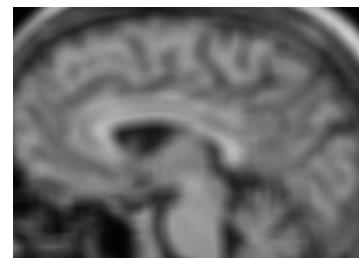
3x3



5x5

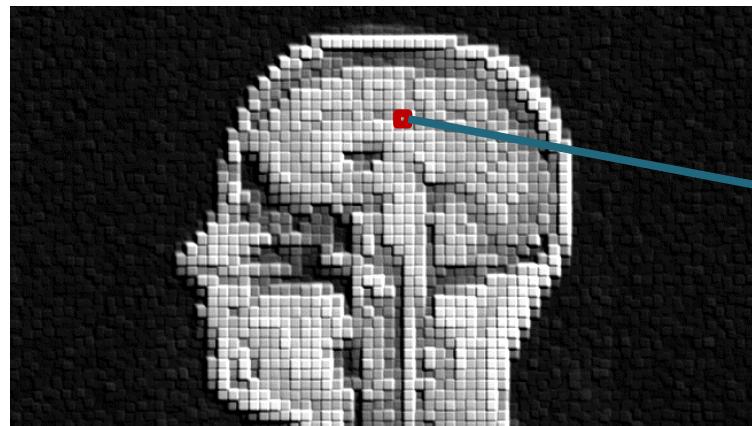


10x10



Median filter

- For each voxel, replace its value by median intensity in its *neighbourhood*



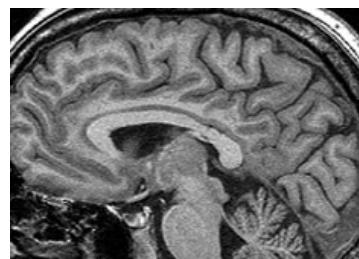
Original values				
20	30	20	23	31
20	25	30	25	20
30	20	90	20	22
25	28	24	26	20
50	12	26	21	23

Filtered values				
		25		

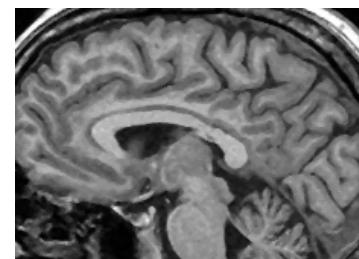
median (25, 30, 25, 20, 90, 20, 28, 24, 26)

Median filter

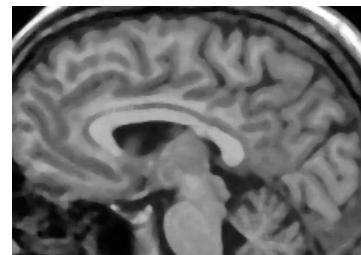
Original



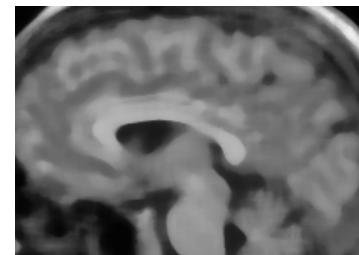
3x3



5x5

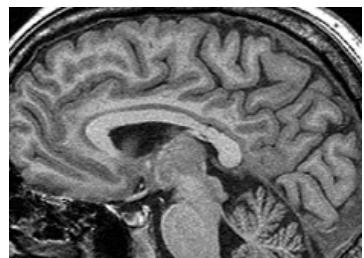


10x10

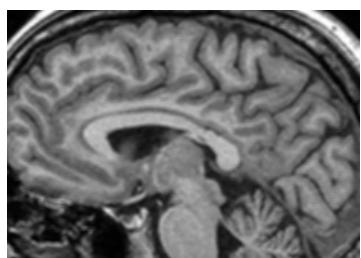


Mean vs median filter

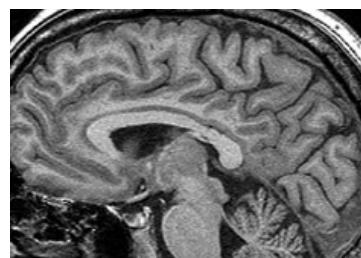
Original



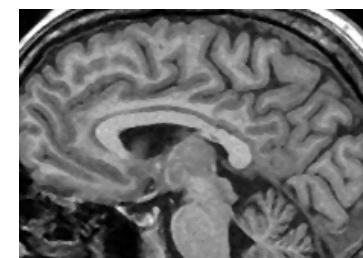
3x3



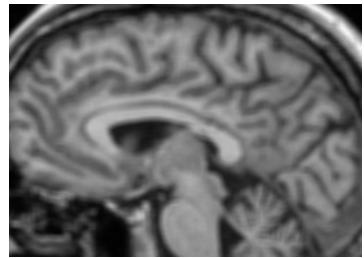
Original



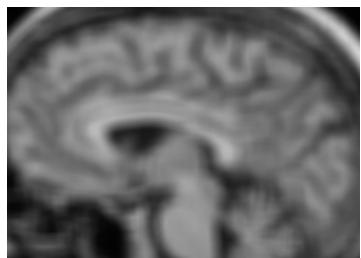
3x3



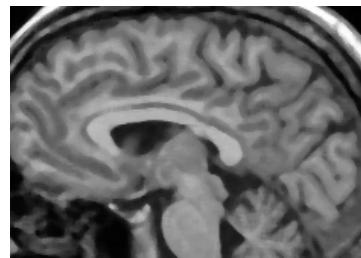
5x5



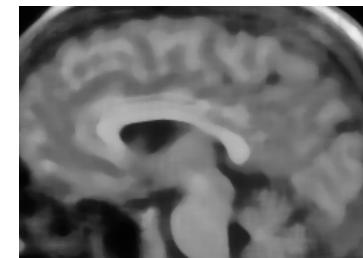
10x10



5x5

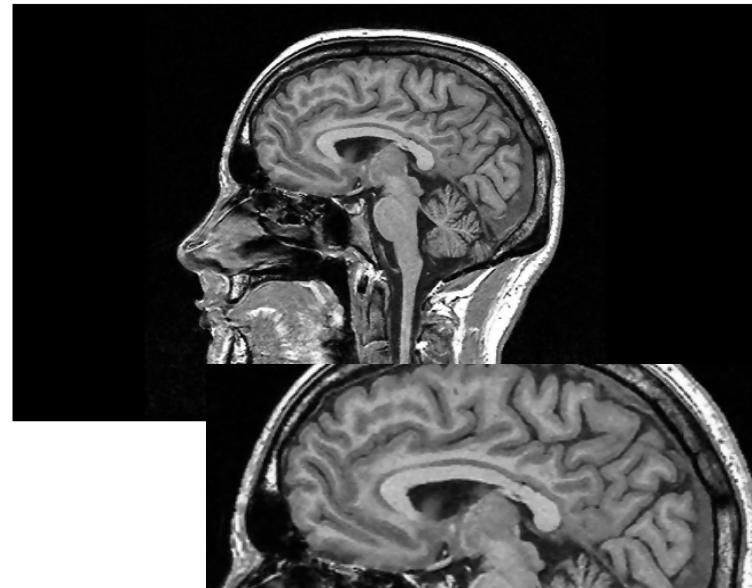
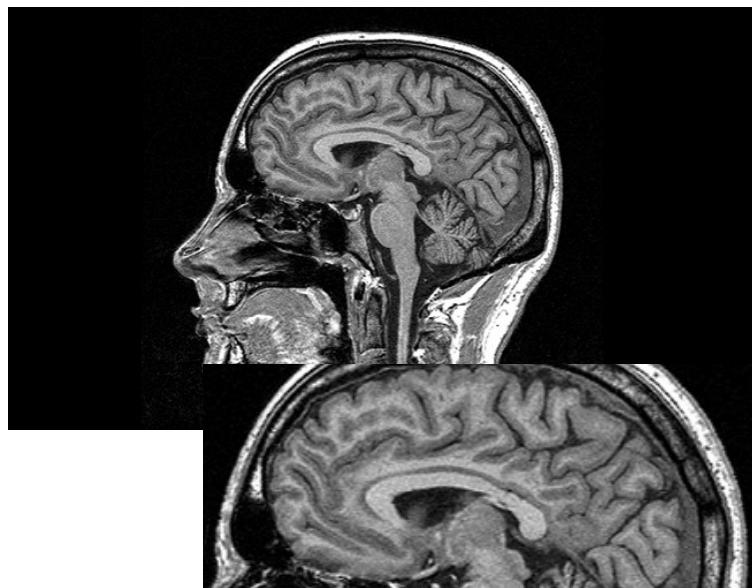


10x10



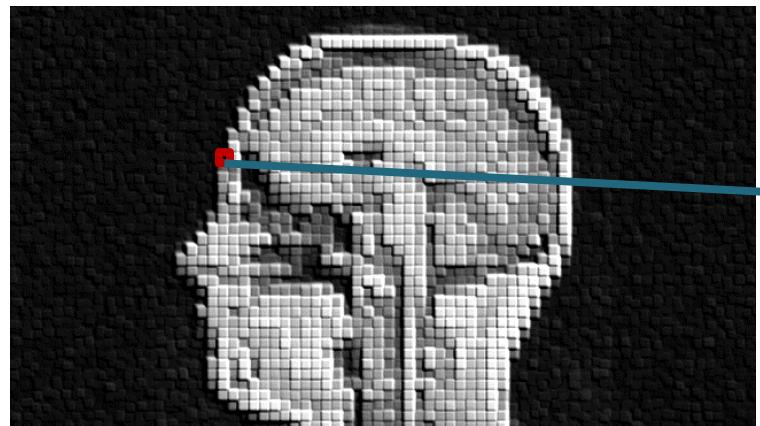
Protecting details from being filtered

- Idea: if edge is detected, do not filter it



Protecting details from being filtered

- Idea: if edge is detected, do not filter it; blur otherwise



Original values

0	0	20	23	31
0	0	30	25	20
0	0	90	20	22
0	0	24	26	20
0	0	26	21	23

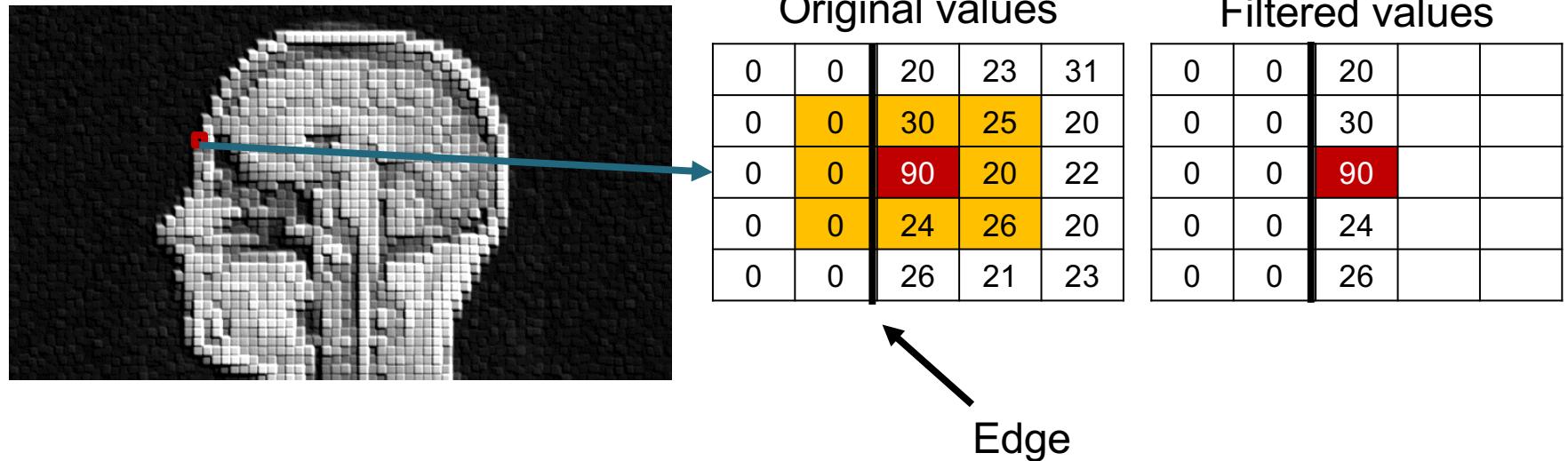
Filtered values

0	0	20		
0	0	30		
0	0	90		
0	0	24		
0	0	26		

Drastic change of
values!

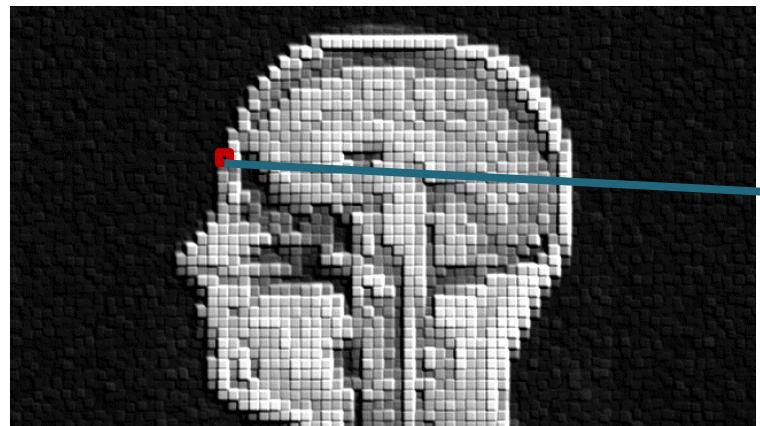
Protecting details from being filtered

- Idea: if edge is detected, do not filter it; blur otherwise



Protecting details from being filtered

- Idea: if edge is detected, do not filter it; blur otherwise



Original values

0	0	20	23	31
0	0	30	25	20
0	0	90	20	22
0	0	24	26	20
0	0	26	21	23

Filtered values

0	0	20	23	25
0	0	30	25	24
0	0	90	20	22
0	0	24	26	22
0	0	26	21	23



University
of Glasgow



Preprocessing

Jose Bernal, BEng MSc PhD (e)

Email: jose.bernal@correounal.edu.co