Truly 3D Midsagittal Plane Extraction for Robust Neuroimage Registration

Leonid Teverovskiy and Yanxi Liu

Center for Automated Learning and Discovery and Robotics Institute

Carnegie Mellon University

# Truly 3D Midsagittal Plane Extraction for Robust Neuroimage Registration

Ideal midsagittal plane (iMSP) is a virtual geometric plane about which the three-dimensional anatomical structure captured in the given neuroimage exhibits maximum bilateral symmetry

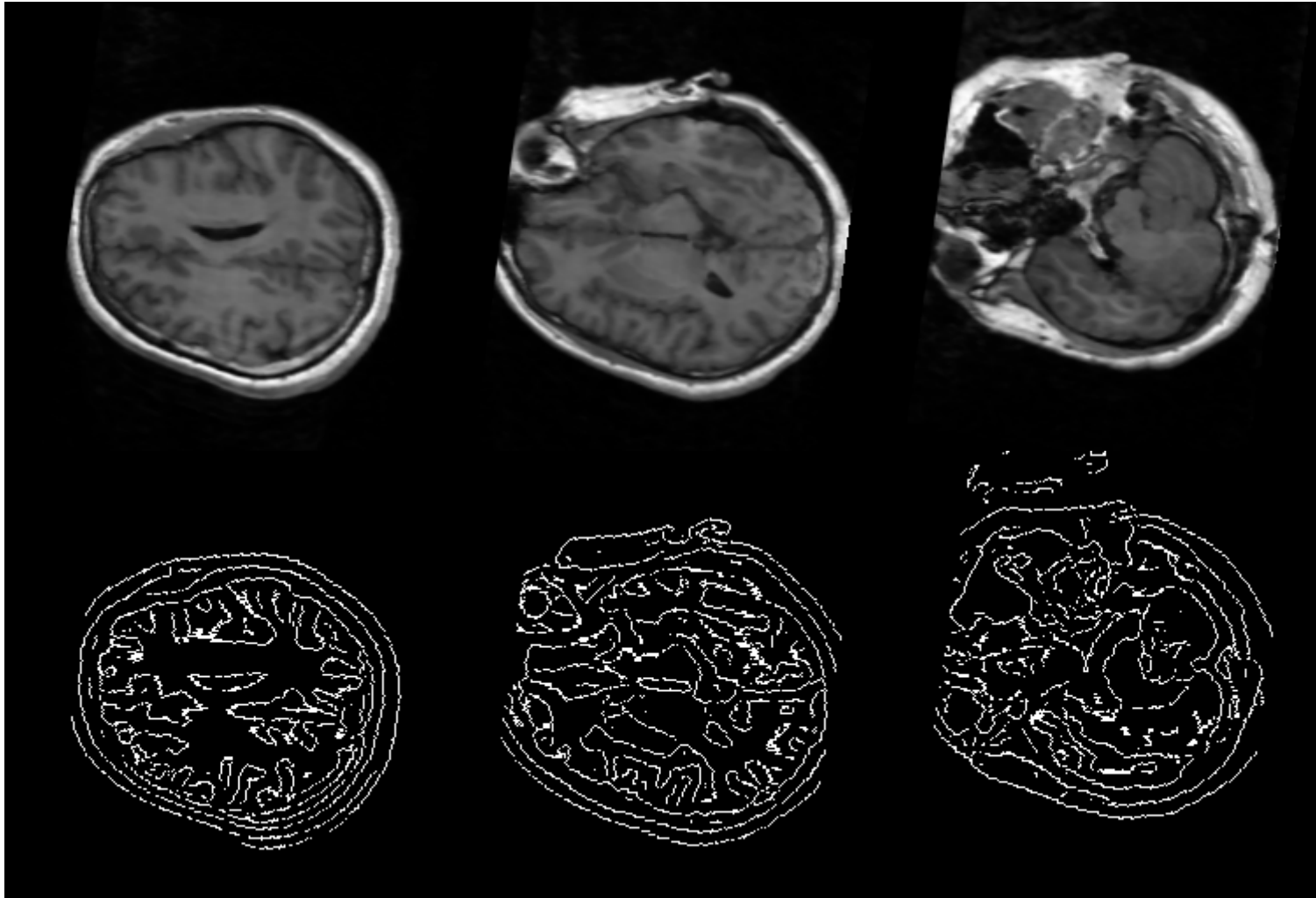Goal: Locate iMSP in an arbitrarily oriented 3D neuroimage.
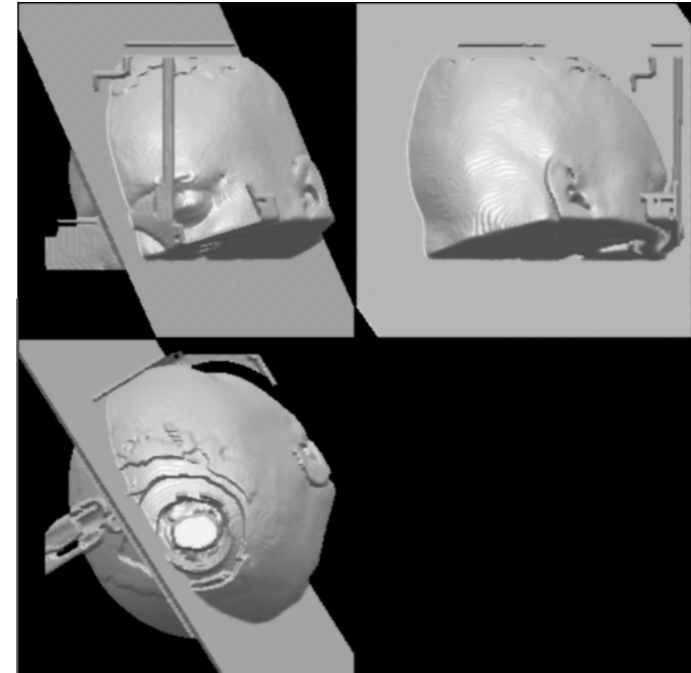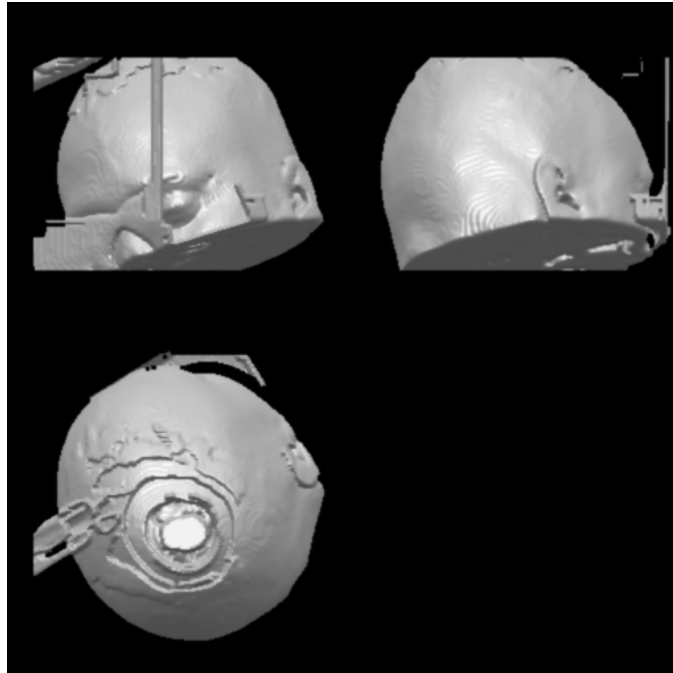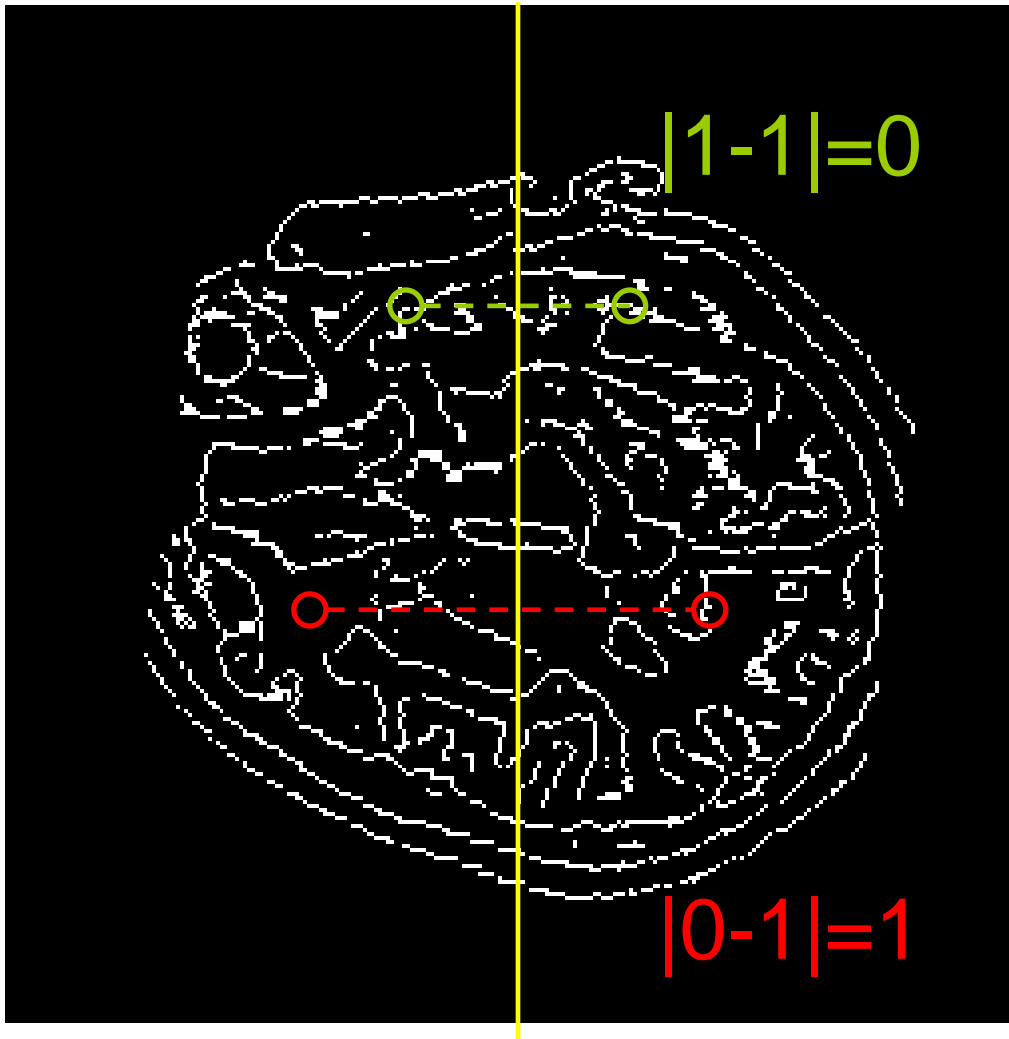
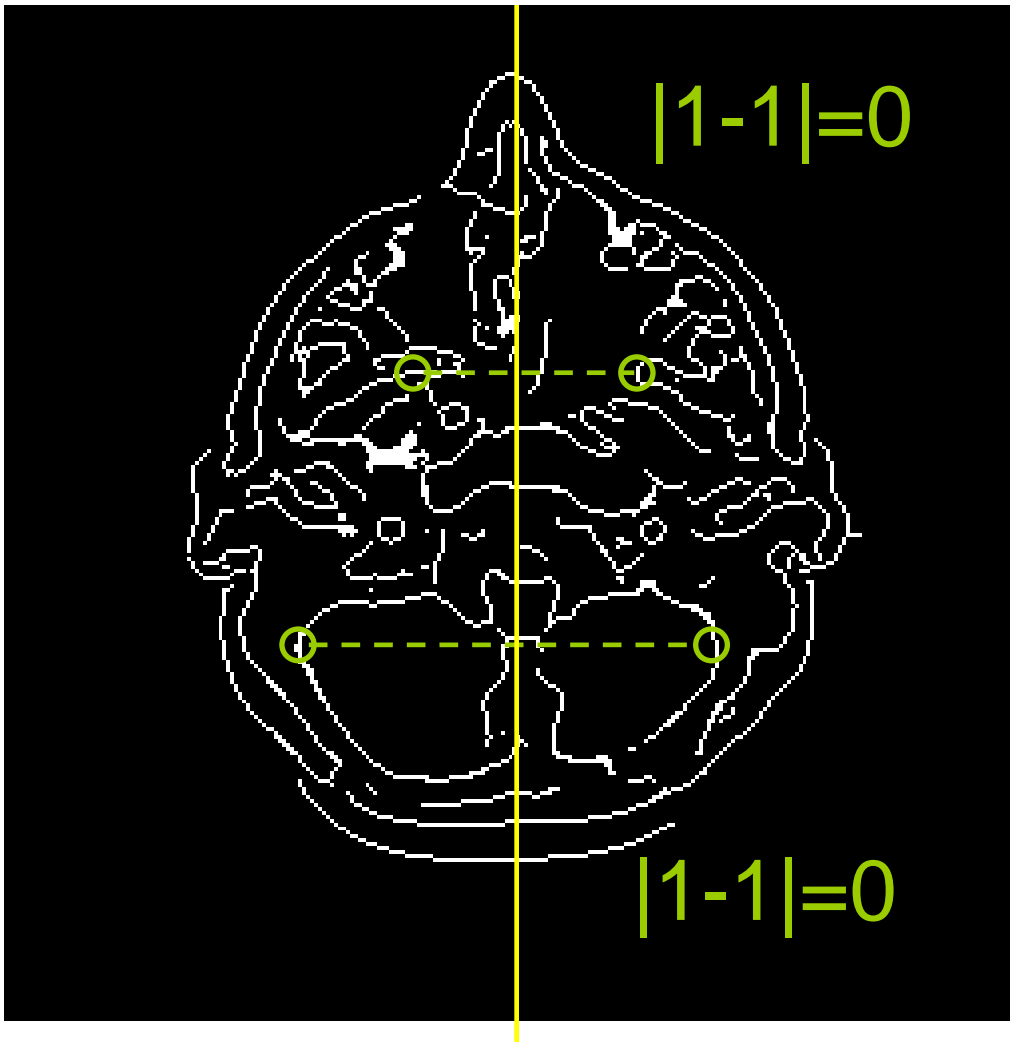# Input data

3D volume represented as 2D slices
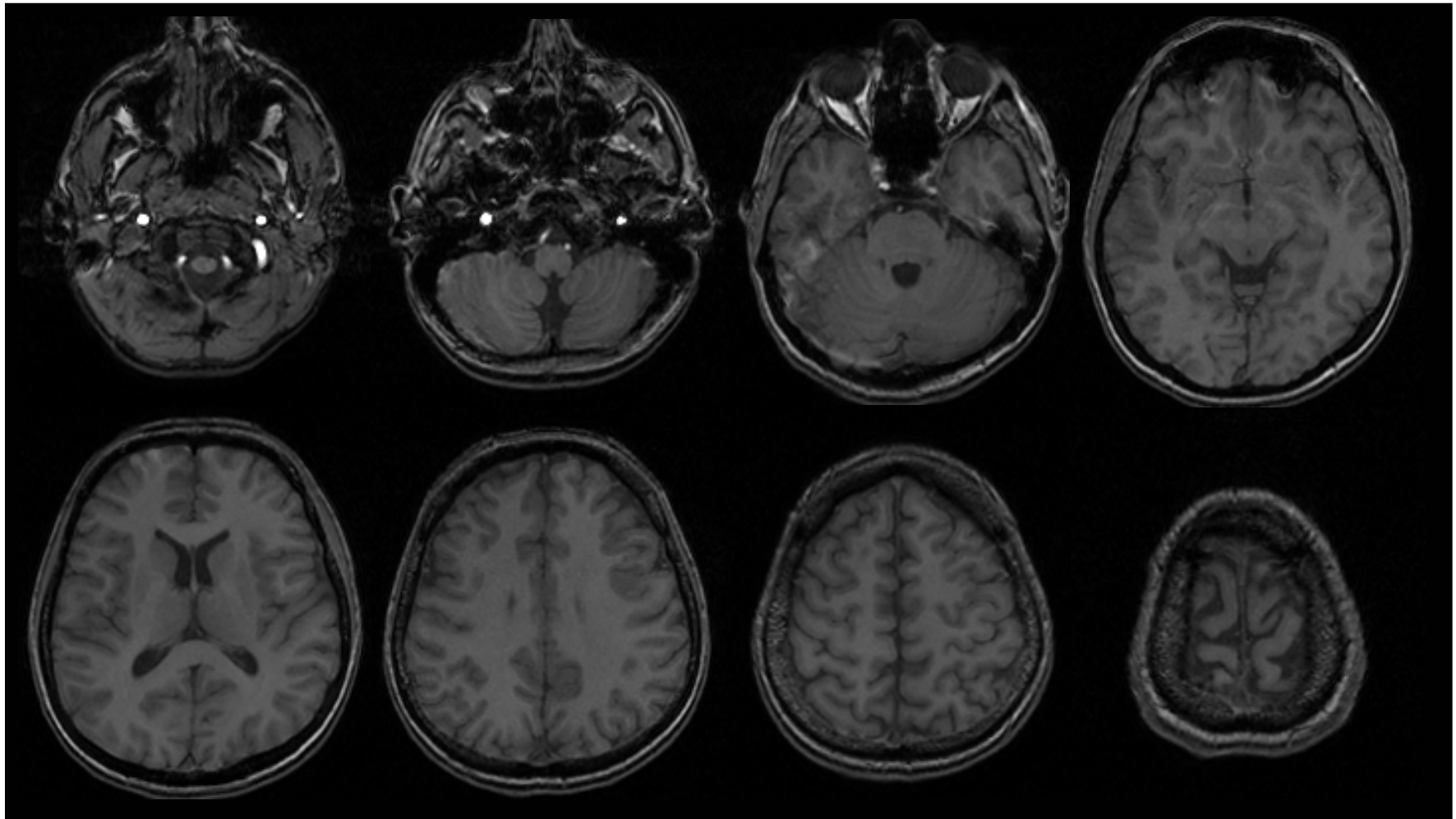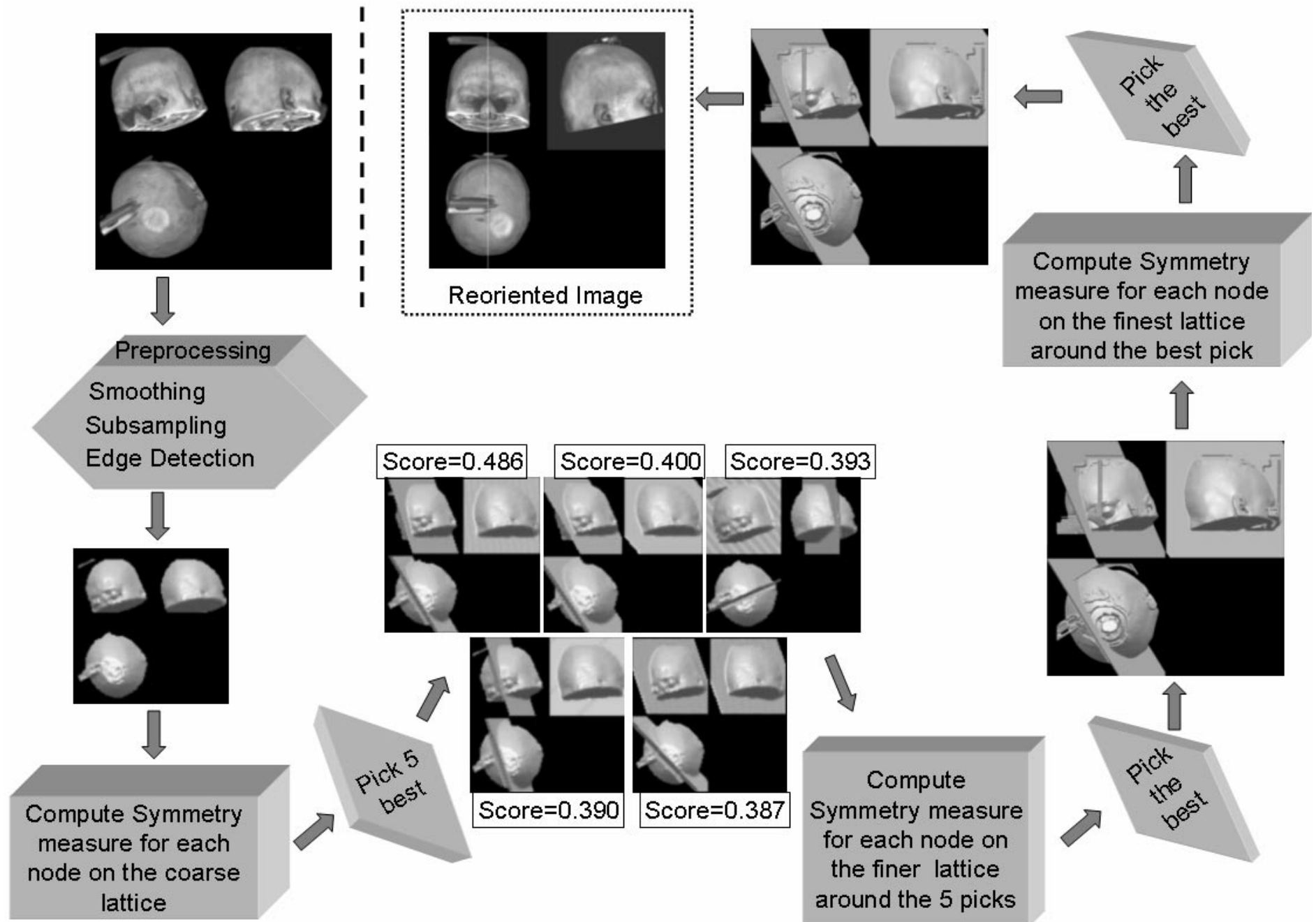
Edge Extraction

Computing asymmetry

|1-1|=0

|0-1|=1

Asymmetric images have high score

Computing asymmetry

|1-1|=0

|1-1|=0

Asymmetric images have low score

Algorithm

Reoriented Image

Preprocessing

Smoothing
Subsampling
Edge Detection

Compute Symmetry
measure for each node
on the finest lattice
around the best pick

Pick the best

Compute Symmetry
measure for each
node on the coarse
lattice

Pick 5 best

Score=0.486 Score=0.400 Score=0.393

Score=0.390 Score=0.387

Compute
Symmetry measure
for each node on
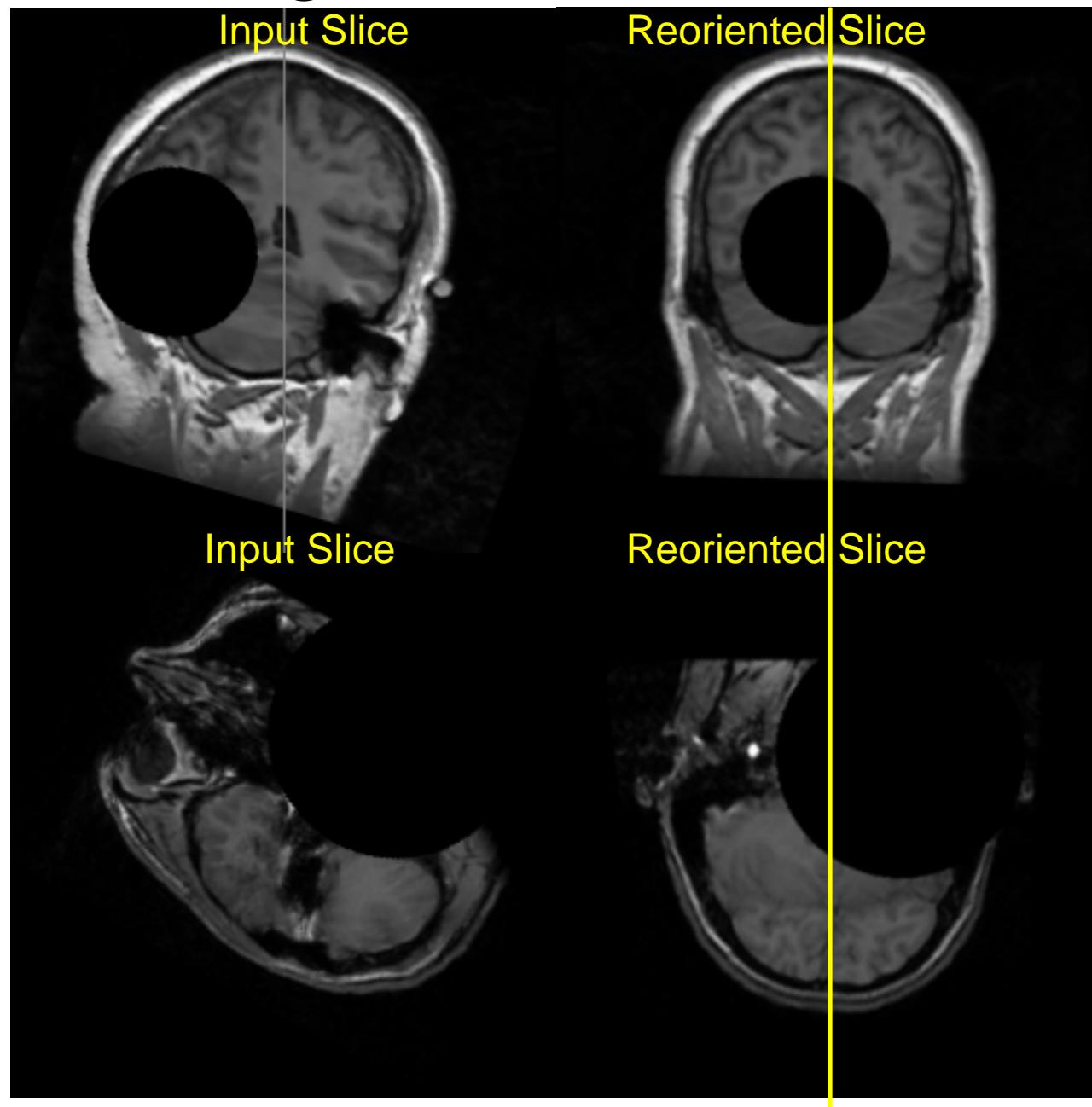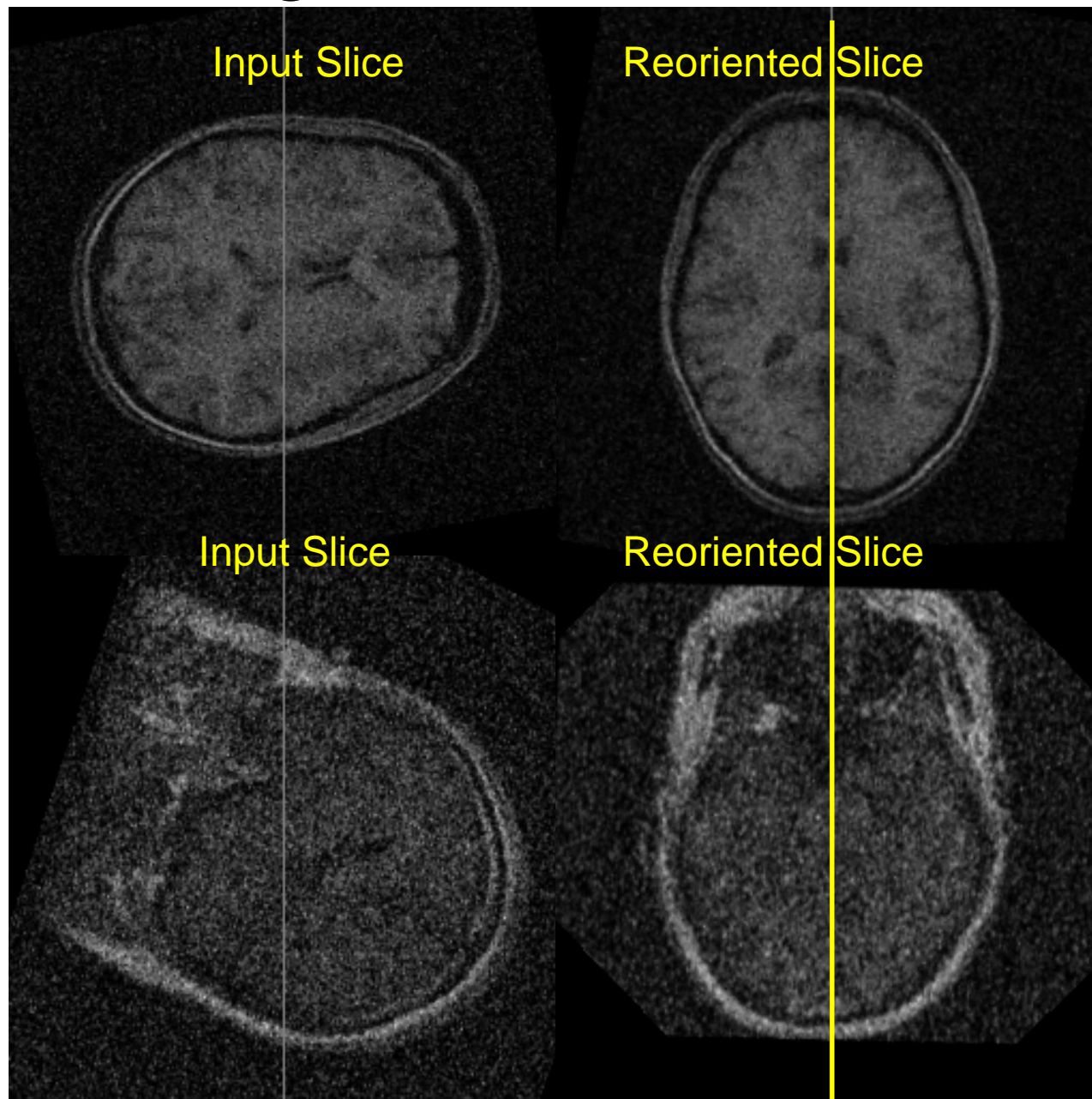the finer lattice
around the 5 picks

Pick the best

Results: normal images
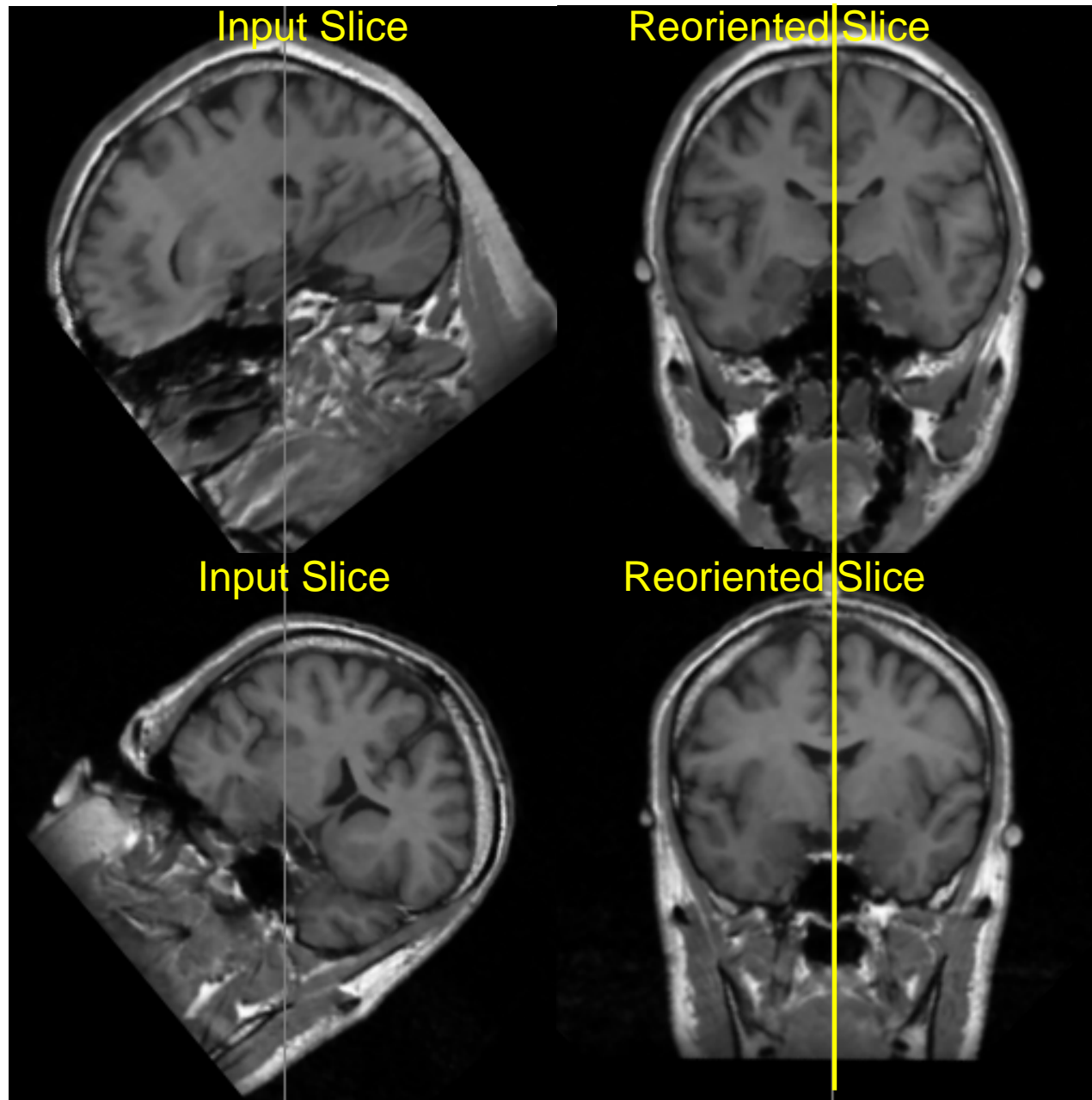
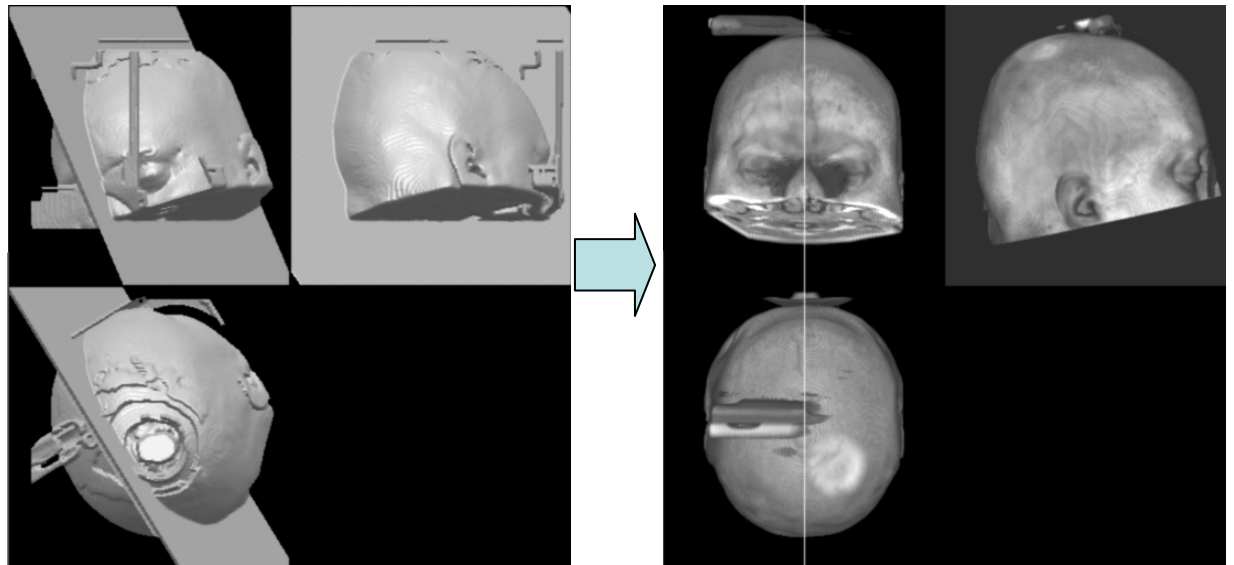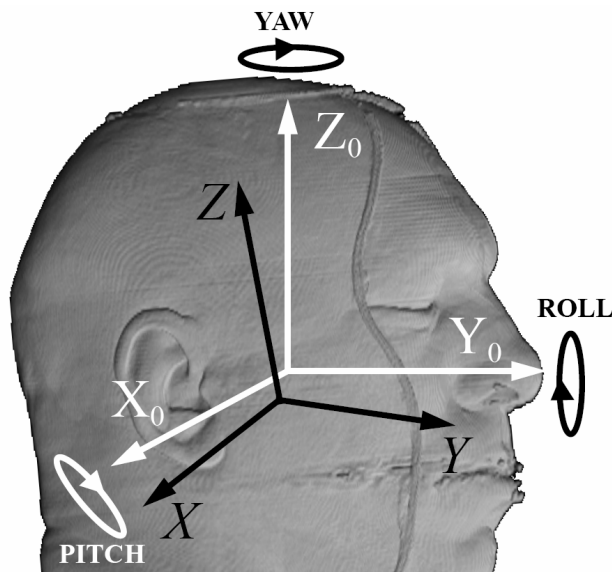# Results: images with simulated tumors

Results: images with simulated noise
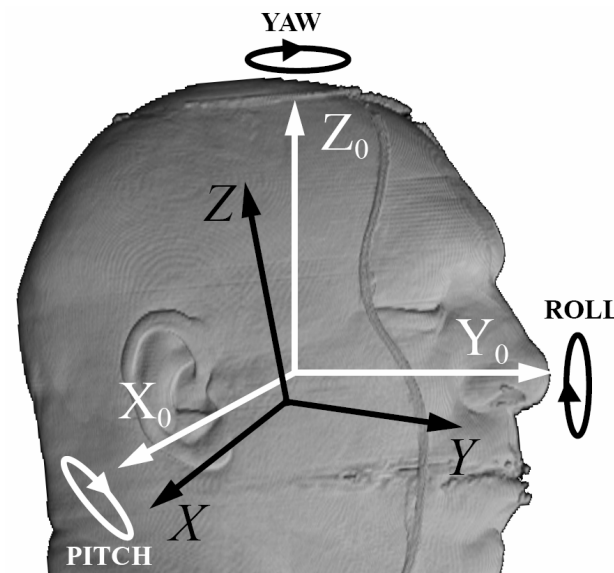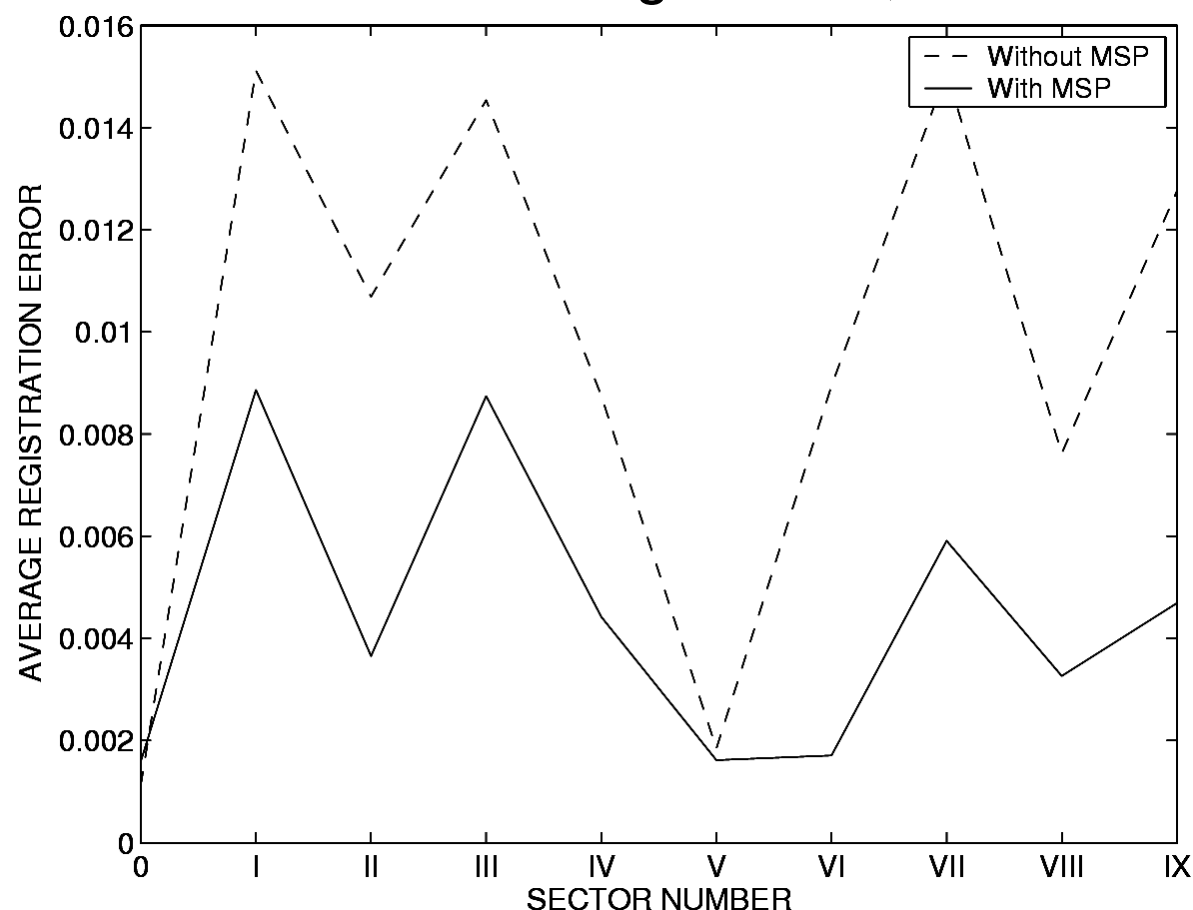
iMSP Extraction and Registration

Reorienting images so that their iMSPs are parallel to yz-plane prior to registration improves registration accuracy and speed

We registered 19 neuroimages, like the one on the right, with rotated versions of themselves, like the one on the left. Each neuroimage was rotated into 10 random orientations with arbitrary yaw and roll angles.

iMSP Extraction and Registration, cont.

The experiments show that for all orientations using iMSP extraction before registration is advantageous. Orientations are partitioned according to which sector contains X axis (axis normal to iMSP). Sector 0: yaw and roll angles are 0. Sector V: small yaw and roll angles. Sectors II, VII: small yaw, large roll. Sectors IV, VI: large yaw, small roll. Sectors I, III, VII, IX: large yaw, large roll.

The graph shows average registration error over 19 neuroimages for each orientation

iMSP Extraction and Registration, cont.
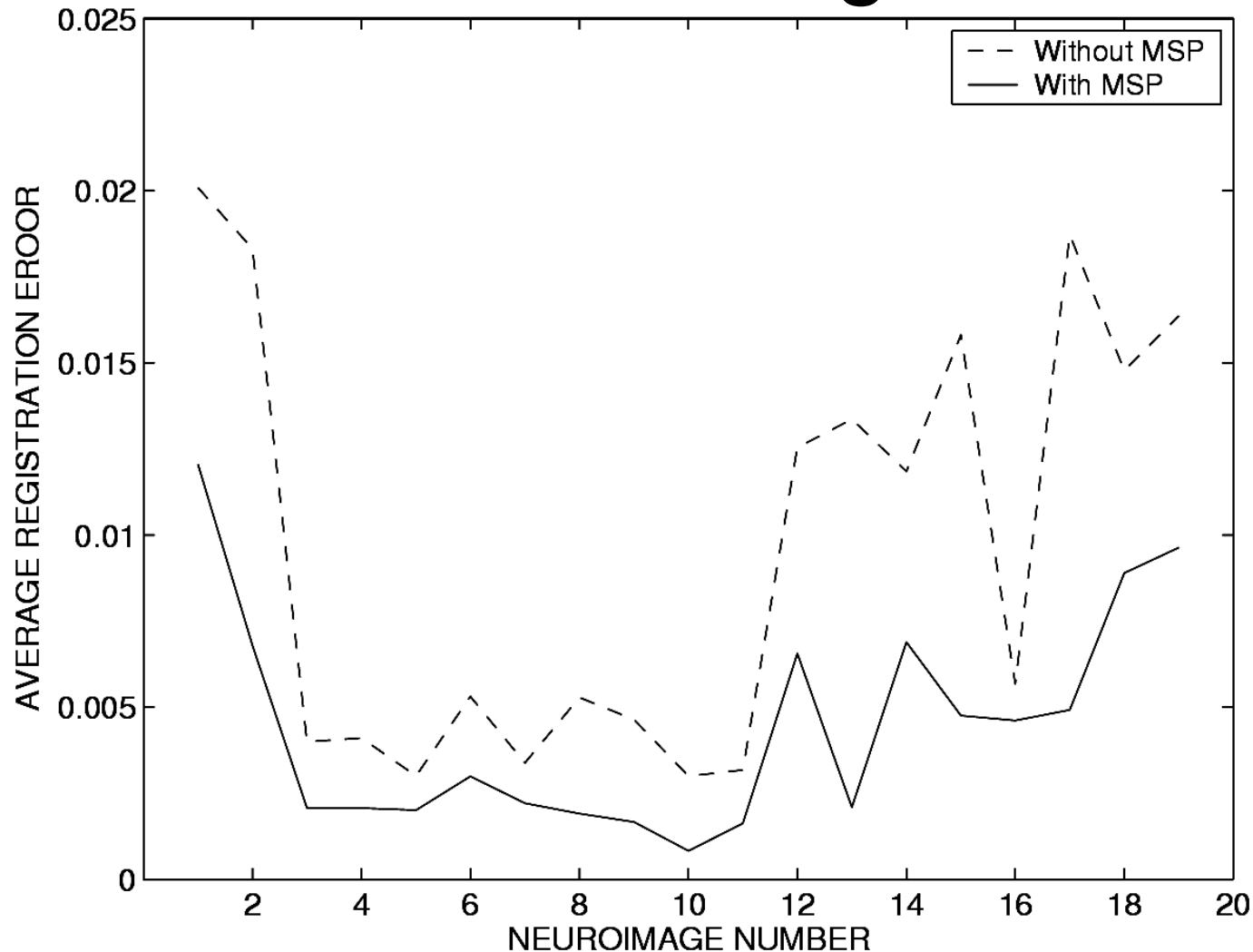
The experiments demonstrate that, for every considered neuroimage, using iMSP extraction before registration was advantageous. The graph shows average registration error over 10 orientations for each neuroimage

Evaluation of the perfomance of the 3D iMSP extraction algorithm

- 19 clinical MR volumes.
- 9 orientations
- Every volume is put into each of 9 orientations.
- Error of the algorithm is averaged over 19 volumes.
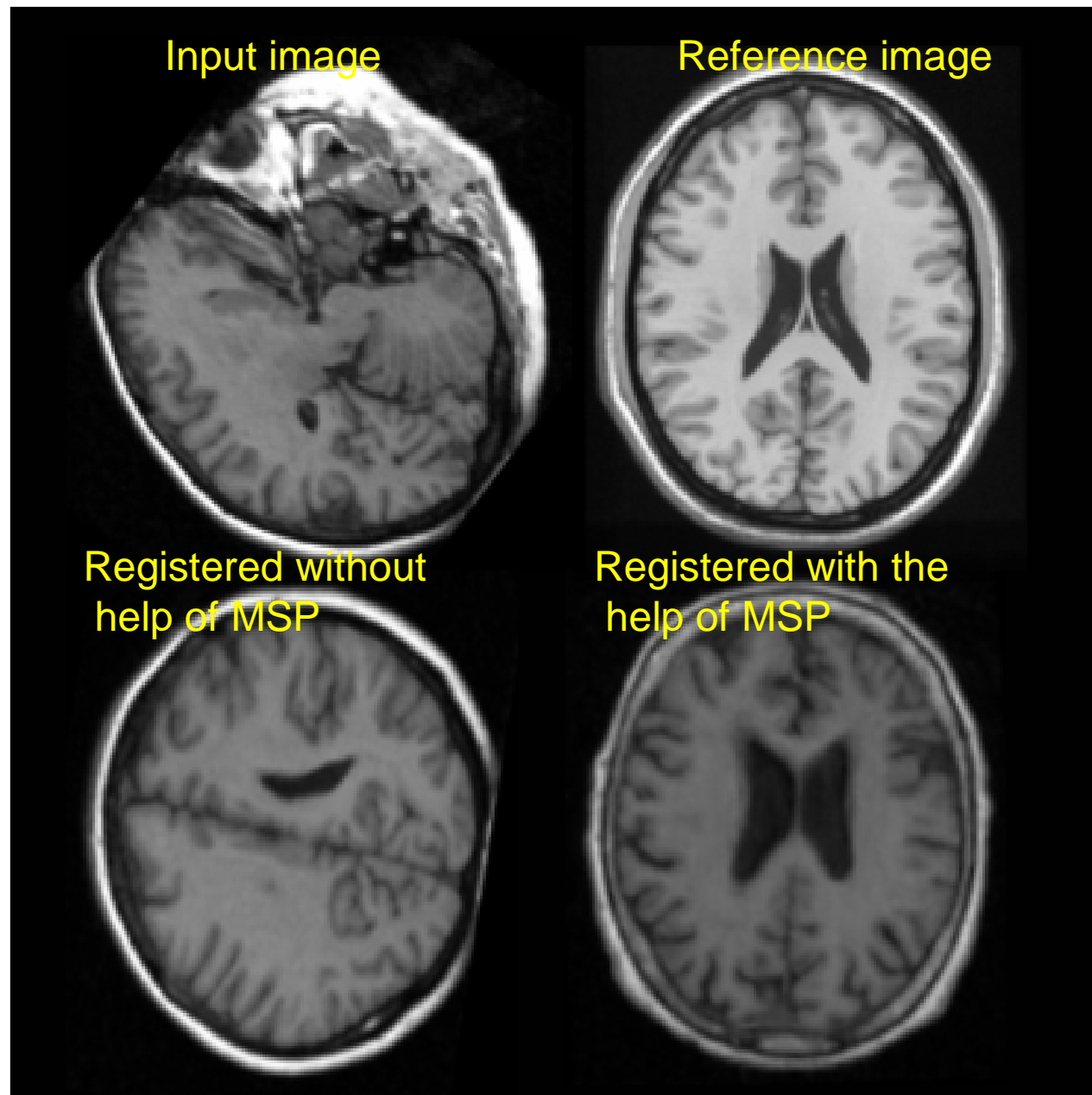
Mean and standard deviation of the error.

Yaw Angle / Roll Angle	[-90; -30]	[-30; 30]	[30; 90]
[-90; -30]	Mean error: 1.115 Error std: 0.946	Mean error: 0.699 Error std: 0.541	Mean error: 1.265 Error std: 1.165
[-30; 30]	Mean error: 0.886 Error std: 0.486	Mean error: 0.554 Error std: 0.420	Mean error: 0.715 Error std: 0.426
[30; 90]	Mean error: 1.137 Error std: 0.781	Mean error: 0.665 Error std: 0.405	Mean error: 1.226 Error std: 0.684

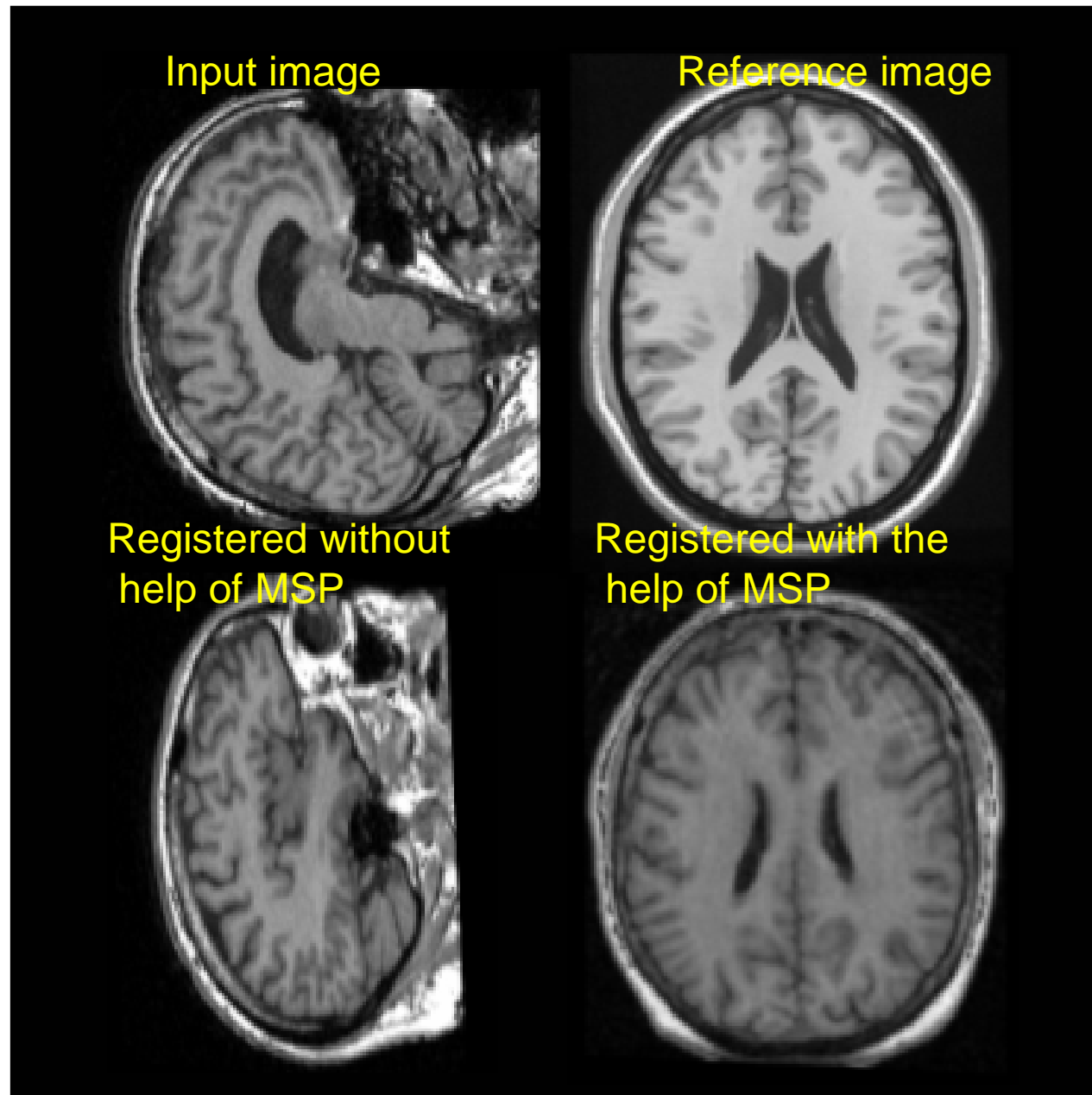Overall mean error is 0.918 degrees with standard deviation of 0.753

iMSP Extraction and Registration, cont.

- iMSP extraction improves accuracy of registration results.
- The improvement is especially significant when the difference in the initial orientations of the images to be registered is large.
- iMSP extraction can be applied to the images of different modalities, and therefore improve multimodality registration.
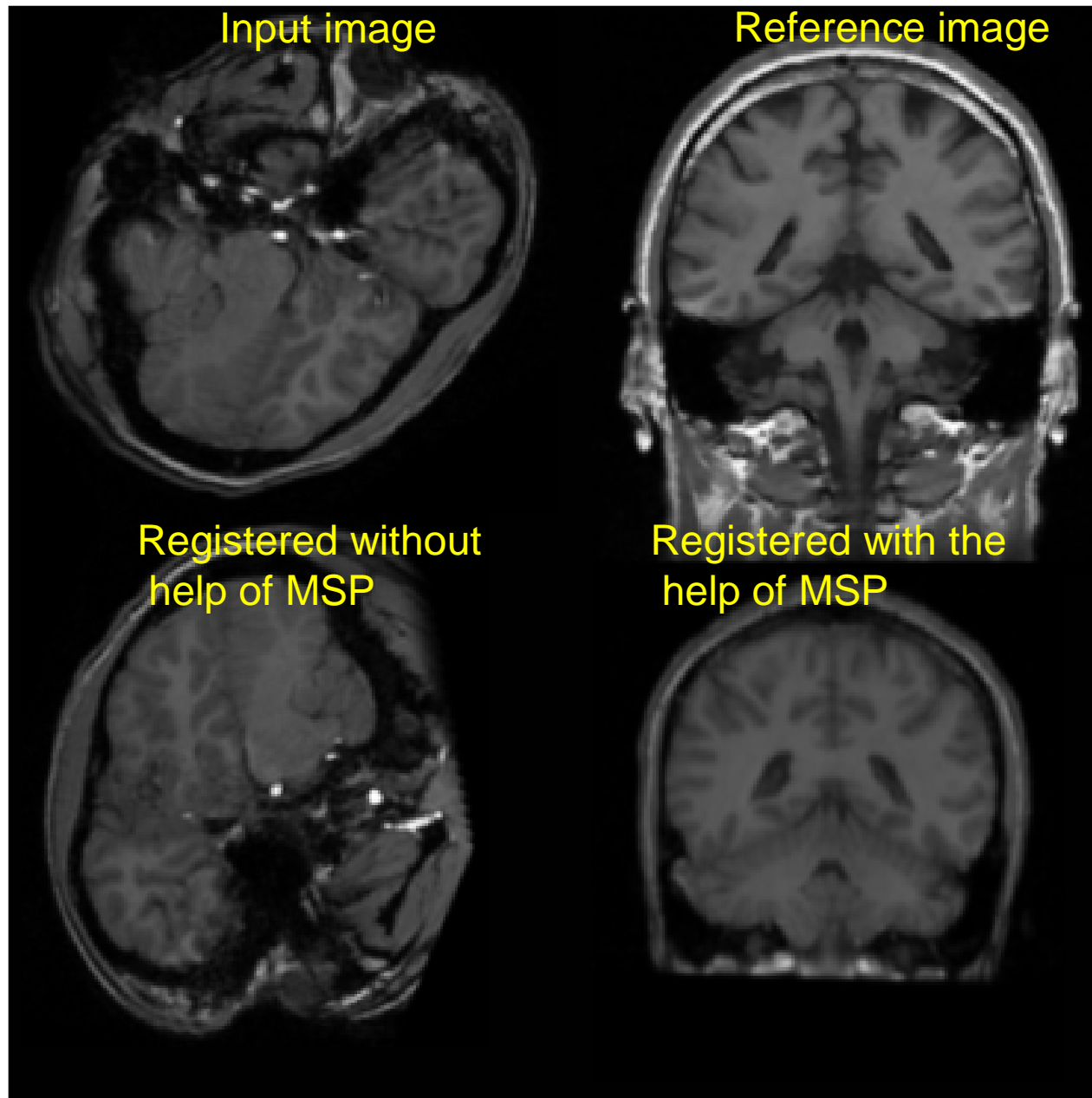
MSP extraction helps registration: results

Input image

Reference image

Registered without help of MSP

Registered with the help of MSP

MSP extraction helps registration: results

MSP extraction helps registration: results

MSP extraction helps registration: results