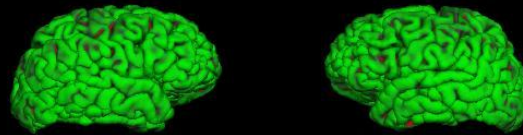
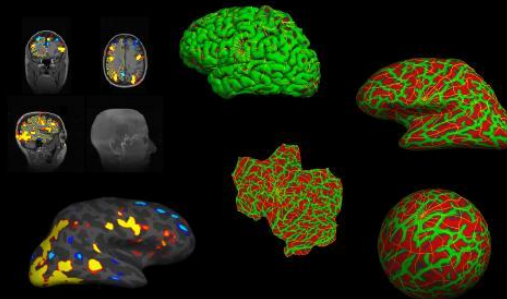


FreeSurfer: Failure Modes and Interventions

surfer.nmr.mgh.harvard.edu



FreeSurfer



MASSACHUSETTS
GENERAL HOSPITAL



Troubleshooting

- Segmentation Errors.
- Intensity Normalization.
- Pial Surface misplacement.
- Skull Strip Errors (none on our test set).

What are the Common Interventions?

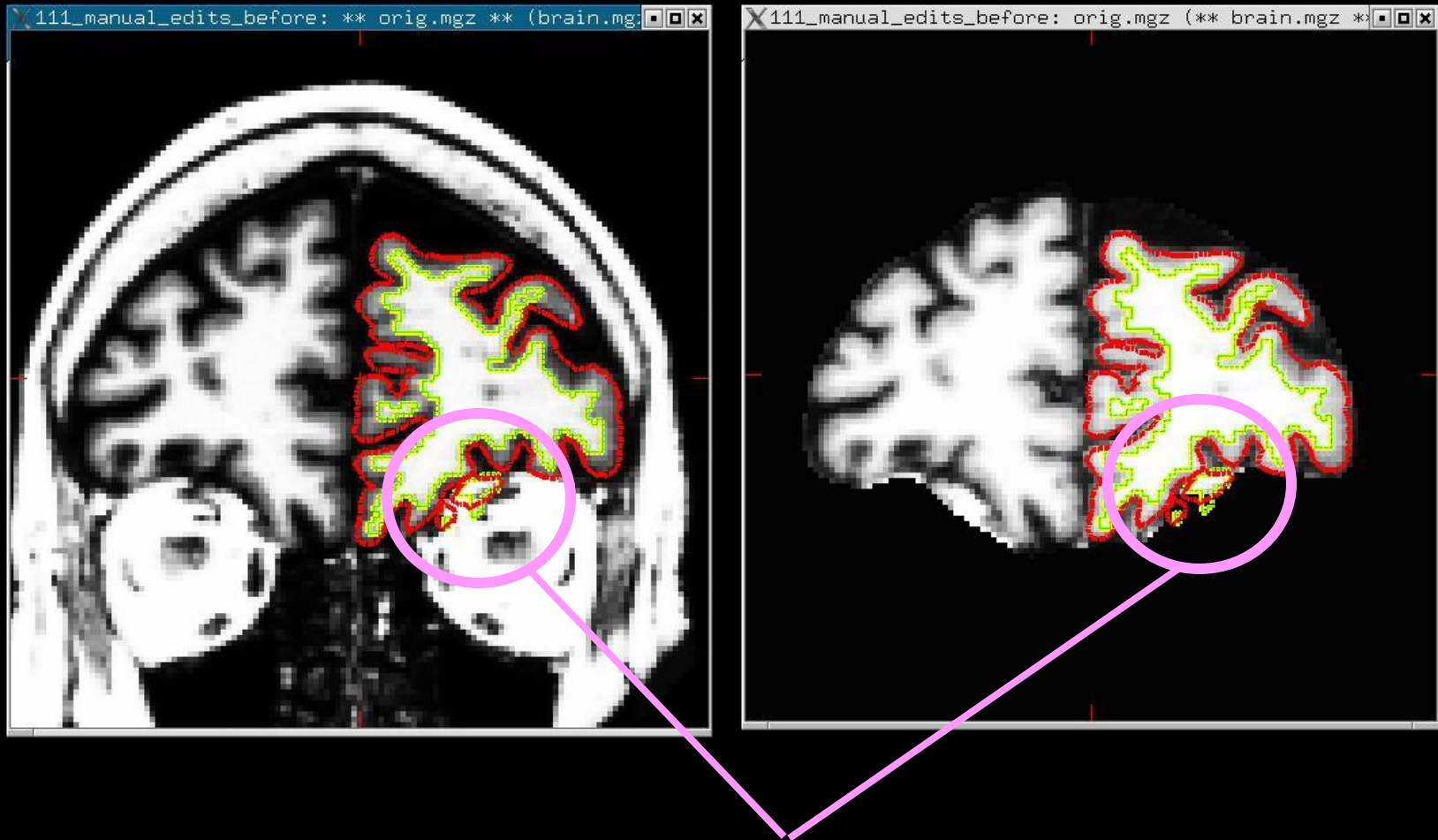
- Manually edit the `wm.mgz` to change incorrectly labeled voxels (only for small errors).
- Manually edit the `brainmask.mgz` to erase dura/vasculature.
- Adjust watershed parameters to fix large-scale skull-strip errors.
- Manually erase/clone regions of skull strip failure.
- Control Points – add locations that are in the interior of the white matter and <110 to bring regional wm intensity up.
- Use `tkregister2` to fix incorrect `talairach.xfm`

Troubleshooting – Common Cases

($\approx 98\%$ of surface accurate in about 98% of cases for good data [1])

- **Symptom:** white matter not accurate in wm.mgz
- **Interventions**
 - add control points (if $\text{wm} \ll 110$).
 - Expert opts to set intensity thresholds in segmentation (almost never).
 - Manually erase/draw wm in wm.mgz
- **Symptom:** skull strip not accurate
- **Interventions**
 - Adjust mri_watershed parameters
 - Manually erase skull/clone T1.mgz to recover brain
- **Symptom:** surfaces are not accurate.
- **Interventions:**
 - Add control points (if white matter $\ll 110$).
 - Erase dura/blood vessels
 - Check topology on ?h.inflated.nofix (if ?h.orig surface doesn't follow wm.mgz)

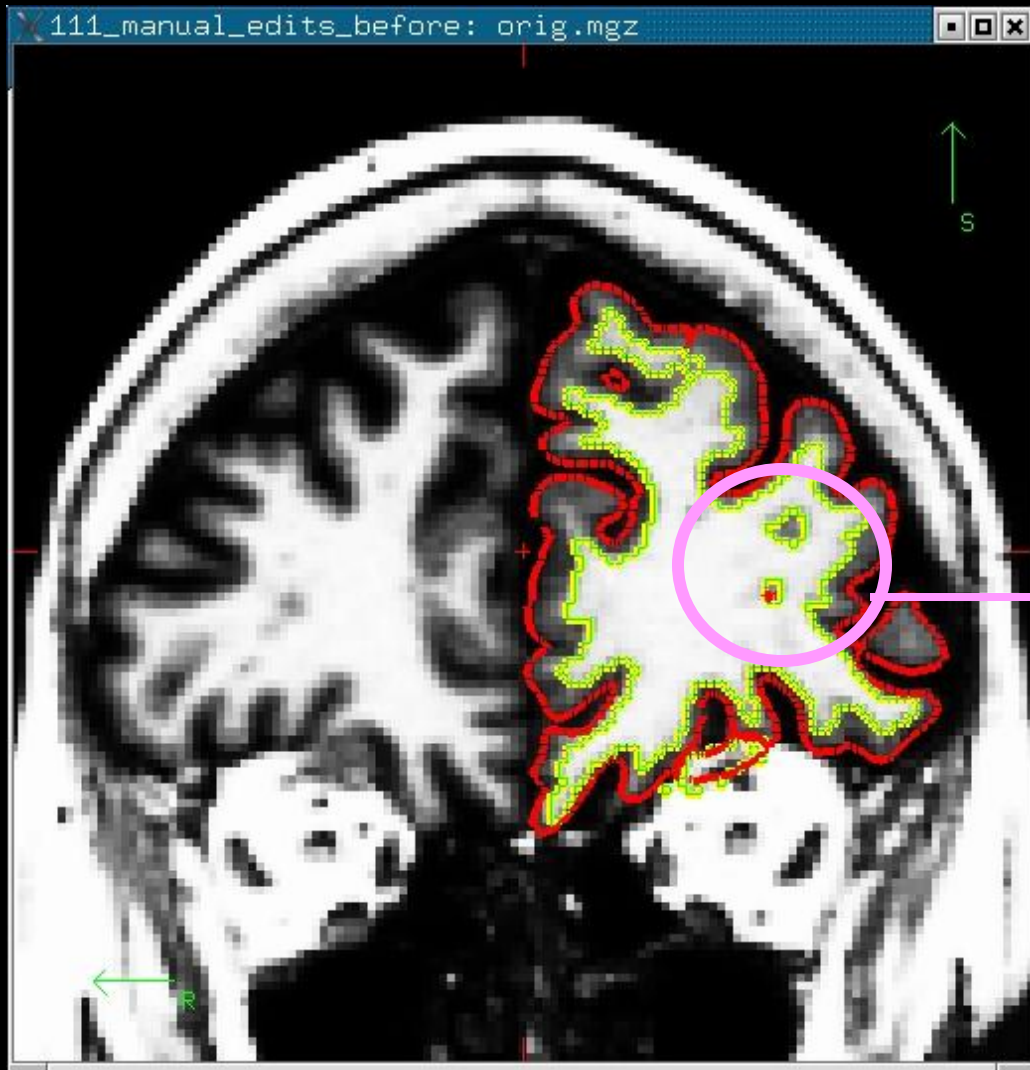
Troubleshooting: Segmentation Error



Eye Socket classified as WM due to Skull Strip Failure.
Erase in wm.mgz then run:

```
recon-all -s <subject> -autorecon2-wm -autorecon3
```

Troubleshooting: Segmentation Error

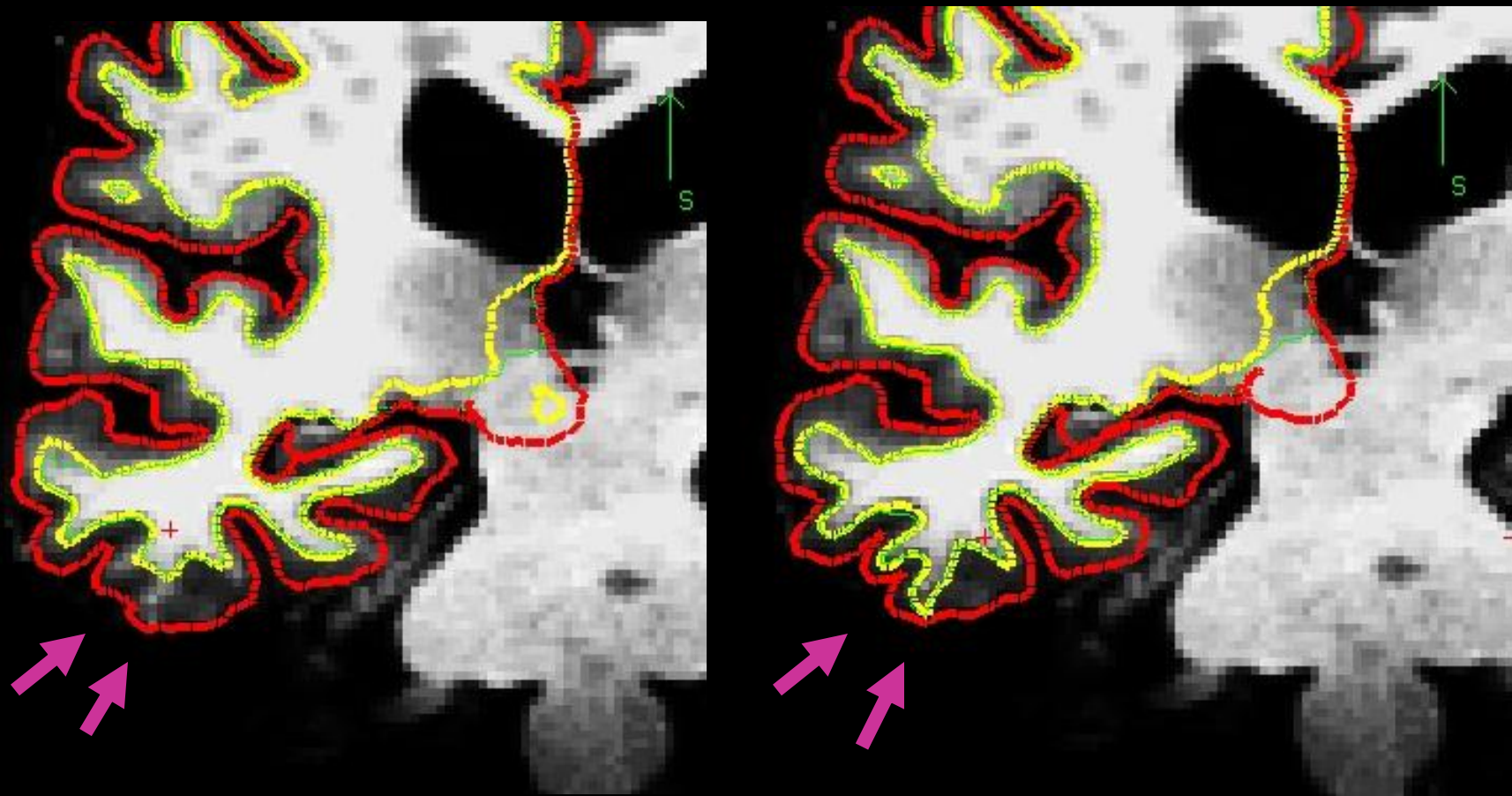


“Hypo-Intensities”
White Matter Lesions
Misclassified as gray
matter

Fill in wm.mgz then run:

```
recon-all -s <subject> -autorecon2-wm -autorecon3
```


Troubleshooting: Intensity Normalization



Intensity Normalization Failure. Most WM in T1 volume (T1.mgz) should be close to 110. Can fix by editing wm.mgz or adding **“Control Points”**. Beware partial voluming!

```
recon-all -s <subject> -autorecon2-cp -autorecon3
```

Troubleshooting: Skull Strip (very rare now)



orig.mgz

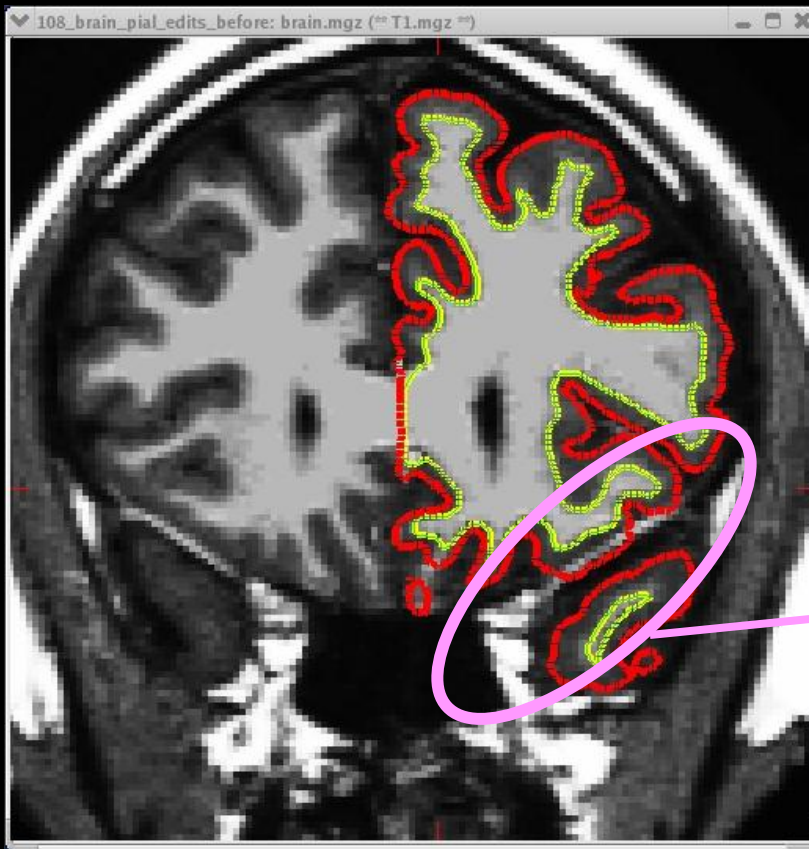


brainmask.mgz

Use “clone” tool to manually correct, or adjust watershed parameters and run (default wsthresh is 25, higher means strip less):

```
recon-all -skullstrip -wsthresh 35 -clean-bm -no-wsgcaatlas -s <subj>  
recon-all -s <subject> -autorecon2 -autorecon3
```


Troubleshooting: Skull Strip/Pial Surface Error

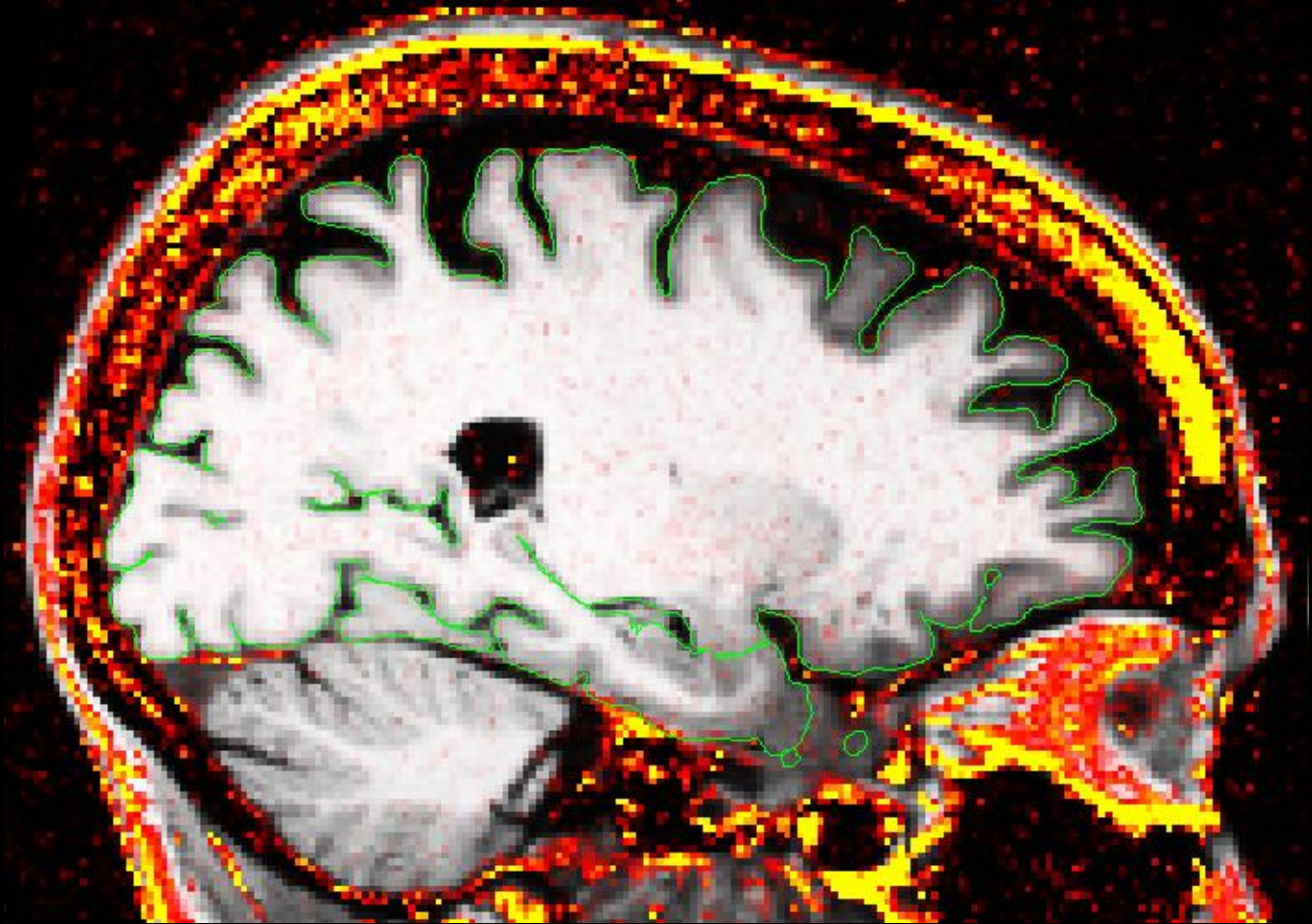


Dura or Blood Vessel
White/Gray OK, but
Pial Inaccurate

Dura and GM have extremely similar intensity characteristics on most T1-weighted sequences (but different T2*!). Typical fix: edit the brainmask.mgz to erase dura/blood vessels, and run:

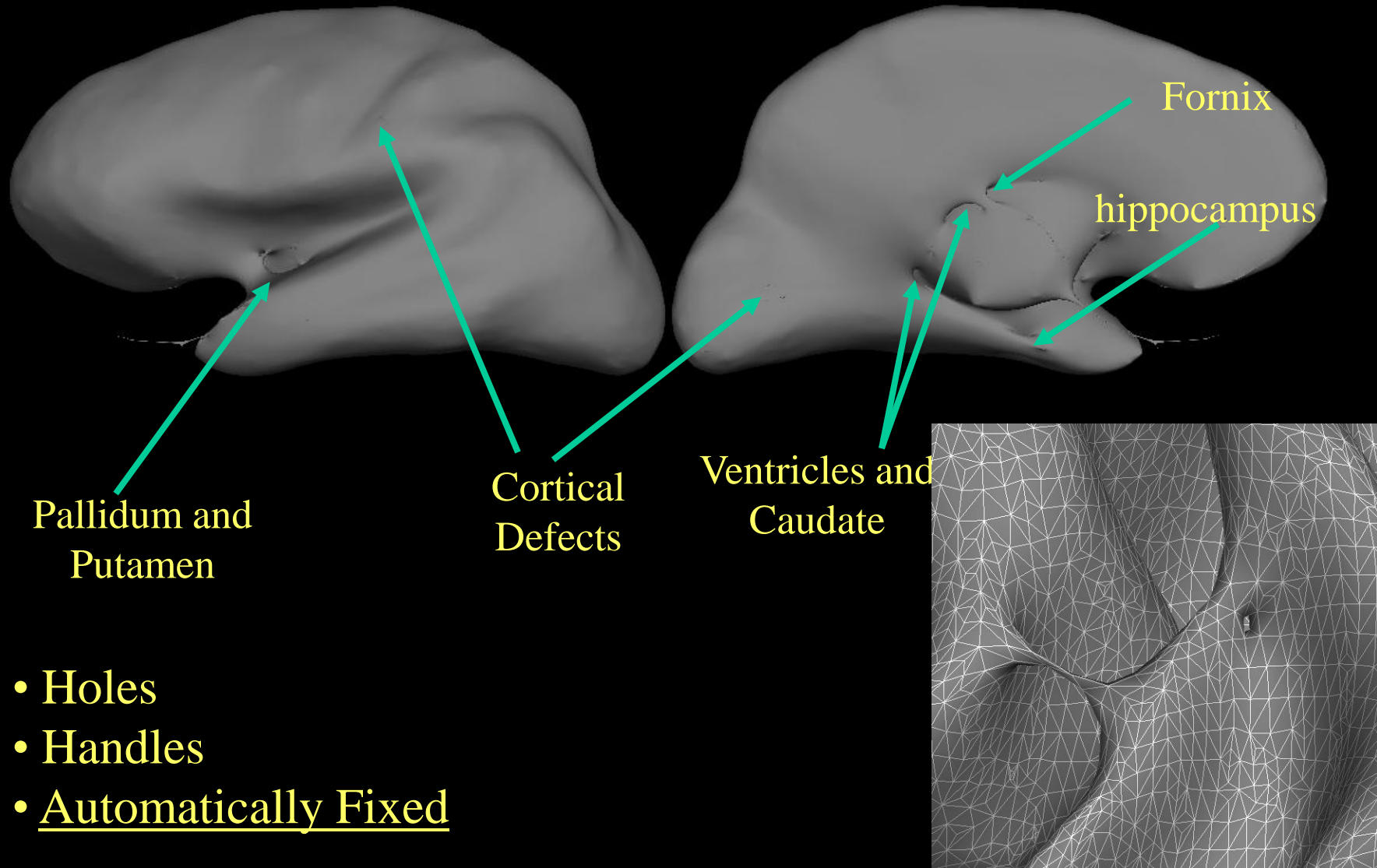
```
recon-all -s <subject> -autorecon2-pial -autorecon3
```

New Morphometry Protocol: Identifying Dura with Multi-echo MP-RAGE

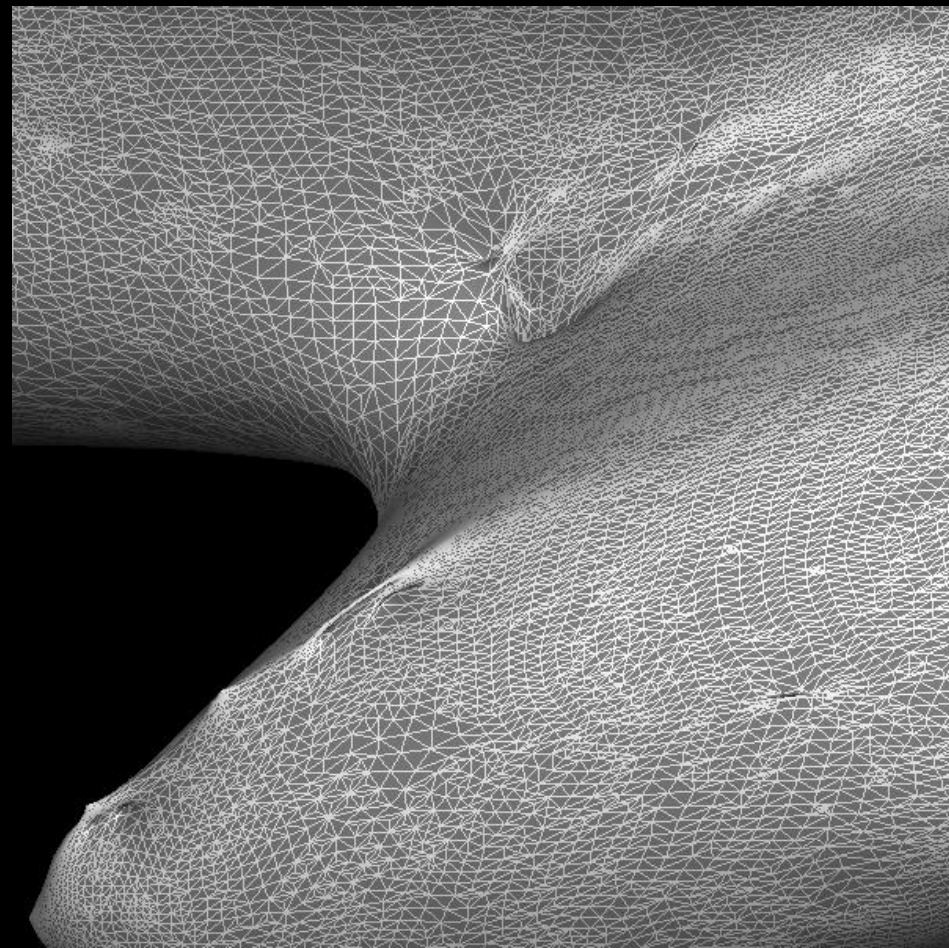


*joint work with Andre van der Kouwe

Troubleshooting: Topological Defects



Topology Correction

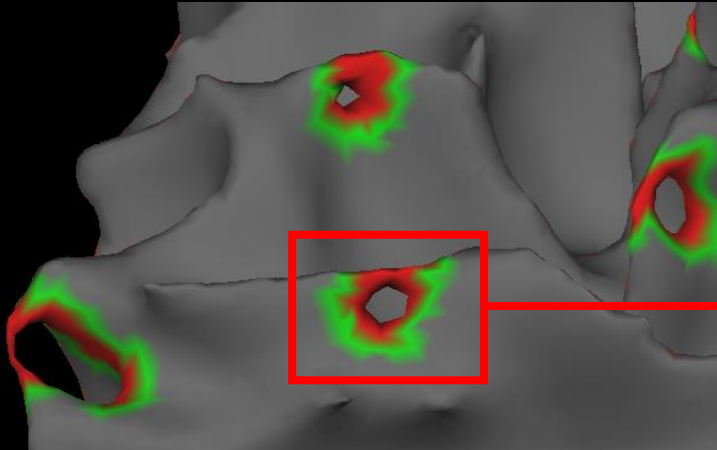


BEFORE

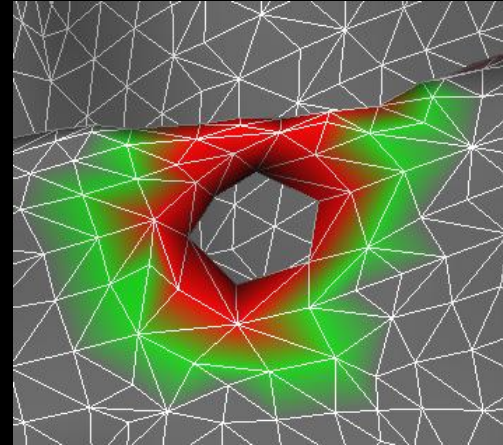


AFTER

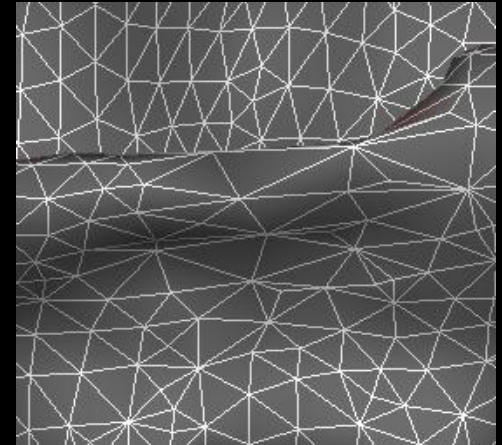
Automatic Defect Correction



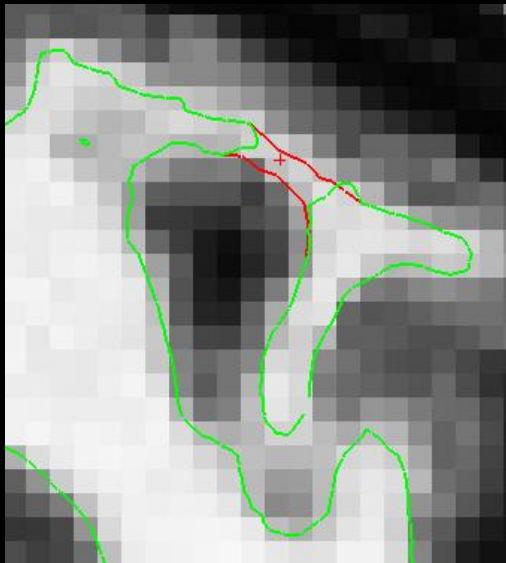
Initial cortical surface



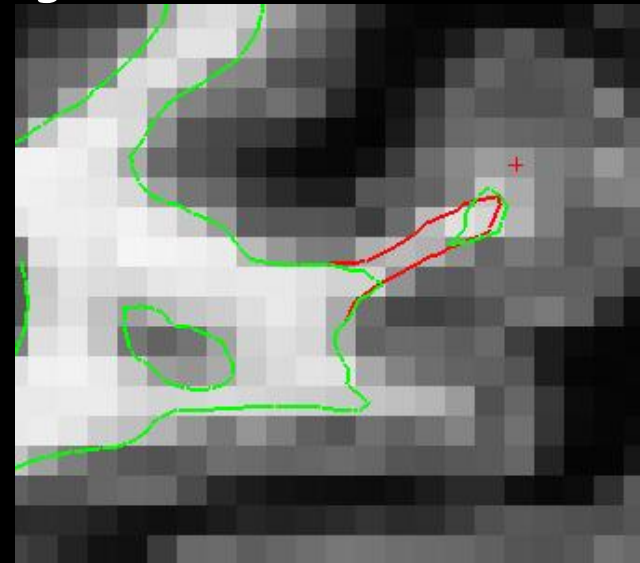
Topological defect



Corrected defect

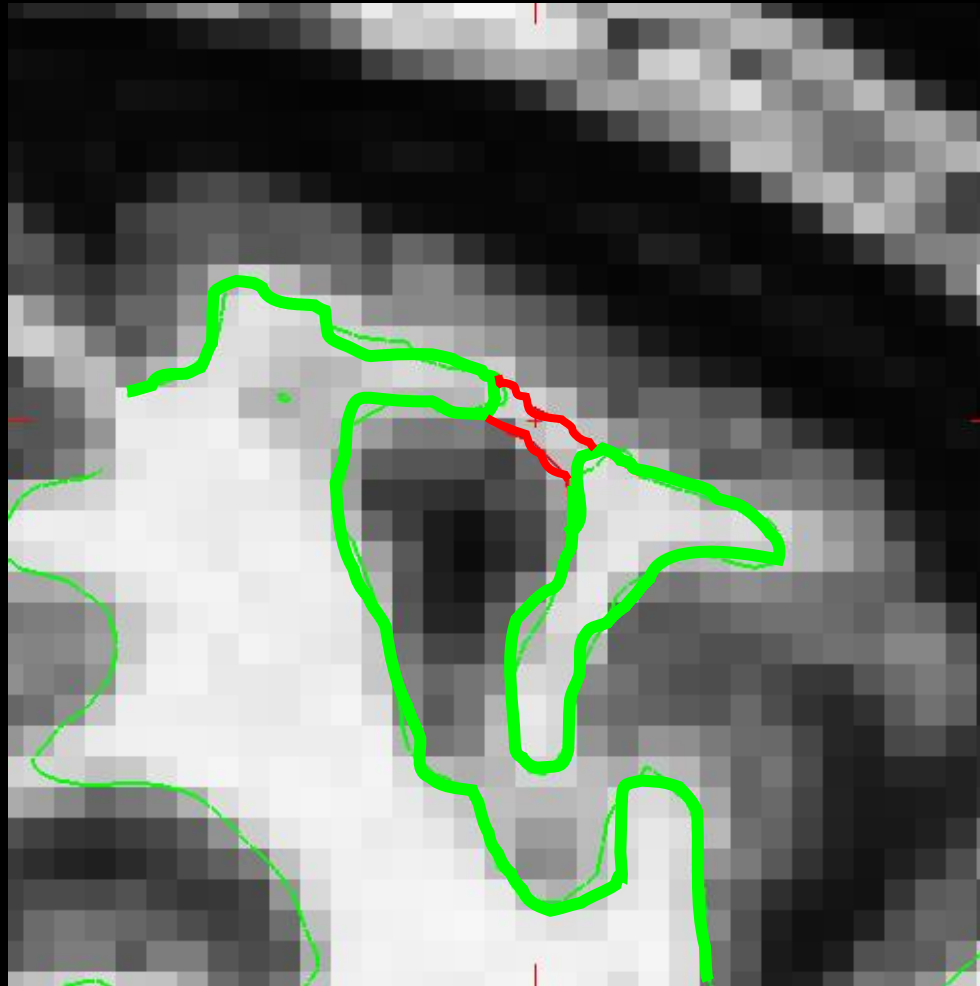


Sagittal view



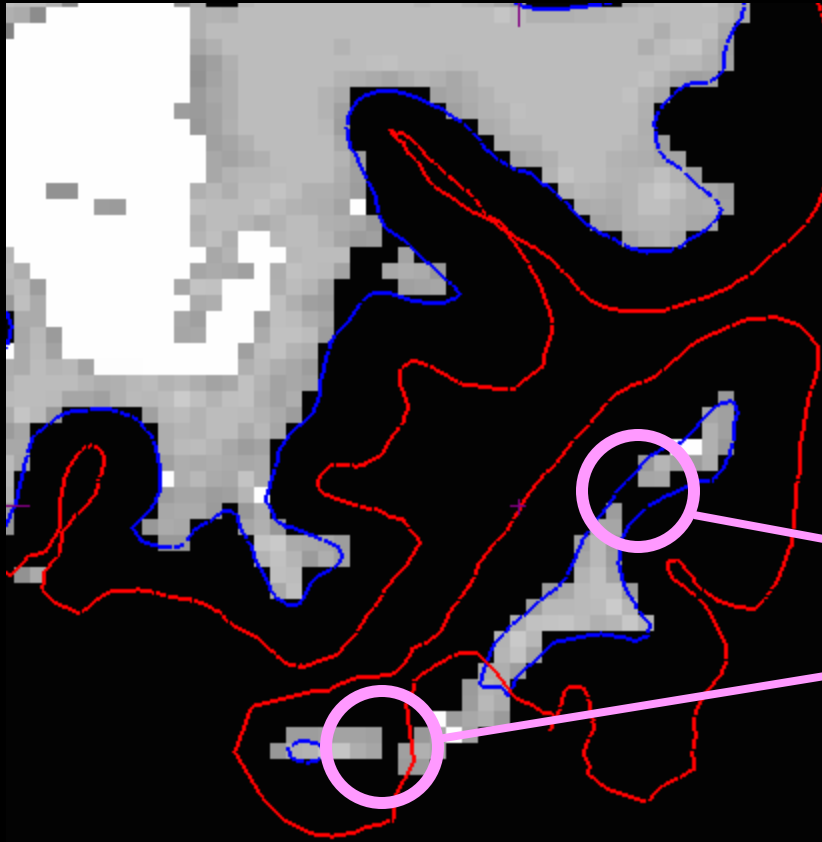
Coronal view

Automatic Defect Correction



Difference between uncorrected (green) and corrected (red)

Troubleshooting: Topology Fixer Error



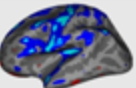
White Matter
“disconnects”

orig.nofix will be
accurate

Troubleshooting – Advice

- Always look at the data in multiple views and scroll back and forth a few slices – 3D structure is difficult to discern!
- If large regions of white matter are significantly darker than 110 (the target white matter intensity for normalization) then try adding control points, but make sure they are in the interior of the white matter.
- If the ?h.orig surface misses white matter that is accurately labeled in the wm.mgz or extends into regions where there is no wm in the wm.mgz, then there is an incorrectly fixed topological defect.
- Even one or two missing voxels can cause large-scale defects, so very minor editing (e.g. filling in white matter voxels that are holes, or erasing handles) may fix the problem.
- Don't edit too much! This will reduce reliability and is almost never needed. Usually this means you need to start over as you've done something wrong (e.g. put control points in the wrong place).

Processing Stream Order

| ReconAllDevTable - Free Surfer Wiki - Mozilla Firefox | | | | |
|---|----------------------------|---|--|---|
| File Edit View Go Bookmarks Tools Help | | | | |
| https://surfer.nmr.mgh.harvard.edu/fswiki/ReconAllDevTable | | | | |
| CentOS Support Gmail Google Calendar Yahoo! The Martinoz Center F Minus FreeSurferWiki Scanner Schedules -astevens Note in Reader Gmail - Inbox - asteve... Martinos Center for Bl... | | | | |
|  ReconAllDevTable | | | | |
| FreeSurferWiki RecentChanges FswikiUpgrade(Read?) FindPage HelpContents ReconAllDevTable | | | | |
| Edit Discussion Info Subscribe Add Link Attachments More Actions: | | | | |
| <h2>FreeSurfer Tutorial: Process Flow</h2> <p>This table shows the recon-all steps for the current dev version of FreeSurfer. See ReconAllStableTablev4 to see a process flow for the latest stable version of FreeSurfer.</p> <p>Click here to see this information presented in a block diagram format and here for a process v. files table.</p> <p>See also the OtherUsefulFlags for other recon-all options.</p> | | | | |
| recon-all step | Individual Flag | Input | Command Line | Output |
| recon-all -autorecon1 -subjid -subjid | -i <invol1> -i <invol2> | invol1.dcm invol2.dcm | mri_convert invol1.dcm orig/001.mgz mri_convert invol2.dcm orig/002.mgz | orig/001.mgz orig/002.mgz |
| | -motioncor | orig/001.mgz orig/002.mgz rawavg.mgz | mri_motion_correct_fsl -o rawavg.mgz -wild orig/001.mgz orig/002.mgz mri_convert rawavg.mgz orig.mgz --conform | rawavg.mgz orig.mgz |
| | -nuintensifycor | orig.mgz | mri_add_xform_to_header -c transforms/talairach.xfm orig.mgz orig.mgz mri_nu_correct_mni -i orig.mgz --o nu.mgz --n 2 | orig.mgz nu.mgz |
| | -talairach | nu.mgz transforms/talairach.auto.xfm transforms/talairach.xfm | talairach_avi -i nu.mgz --xfm transforms/talairach.auto.xfm cp transforms/talairach.auto.xfm transforms/talairach.xfm talairach_afd -T 0.005 -xfm transforms/talairach.xfm | transforms/talairach.auto.xfm transforms/talairach.xfm transforms/talairach.xfm |
| | -normalization | nu.mgz | awk -F \$FREESURFER_HOME/bin/extract_talairach_avi_QA.awk transforms/talairach_avi.log mri_normalize -g 1 nu.mgz T1.mgz | transforms/talairach_avi.log T1.mgz |
| | -skullstrip | nu.mgz T1.mgz brainmask.auto.mgz | mri_em_register -skull nu.mgz \$FREESURFER_HOME/average/RB_all_withskull_2007-08-08.gca transforms/talairach_with_skull.ita mri_watershed -T1 -brain_atlas \$FREESURFER_HOME/average/RB_all_withskull_2007-08-08.gca transforms/talairach_with_skull.ita T1.mgz brainmask.auto.mgz cp brainmask.auto.mgz brainmask.mgz | transforms/talairach_with_skull.ita brainmask.auto.mgz brainmask.mgz |
| | -gcareg | brainmask.mgz nu.mgz | mri_em_register -mask brainmask.mgz nu.mgz \$FREESURFER_HOME/average/RB_all_2007-08-08.gca transforms/talairach.ita | transforms/talairach.ita |
| | -canorm | nu.mgz transforms/talairach.ita brainmask.mgz | mri_ca_normalize -mask brainmask.mgz nu.mgz \$FREESURFER_HOME/average/RB_all_2007-08-08.gca transforms/talairach.ita norm.mgz | norm.mgz |
| | -careg | transforms/talairach.ita transforms/talairach.m3z norm.mgz | mri_ca_register -align-after -nobigventricles -mask brainmask.mgz -T transforms/talairach.ita norm.mgz \$FREESURFER_HOME/average/RB_all_2007-08-08.gca transforms/talairach.m3z | transforms/talairach.m3z |
| | -careginv | transforms/talairach.m3z | mri_ca_register -invert-and-save transforms/talairach.m3z | transforms/talairach.m3z.invx.mgz transforms/talairach.m3z.invy.mgz transforms/talairach.m3z.invz.mgz |
| | -rmneck | nu.mgz transforms/talairach.m3z | mri_remove_neck -radius 25 nu.mgz transforms/talairach.m3z \$FREESURFER_HOME/average/RB_all_2007-08-08.gca nu_noneck.mgz | nu_noneck.mgz |
| | -skull-ita | transforms/talairach.ita nu_noneck.mgz | mri_em_register -skull -i transforms/talairach.ita nu_noneck.mgz \$FREESURFER_HOME/average/RB_all_withskull_2007-08-08.gca transforms/talairach_with_skull.ita | transforms/talairach_with_skull.ita |
| | -calabel | norm.mgz transforms/talairach.m3z asen.auto.noCCseg.mgz | mri_ca_label -align -nobigventricles norm.mgz transforms/talairach.m3z \$FREESURFER_HOME/average/RB_all_2007-08-08.gca asseq.auto.noCCseg.mgz mri_cc -asen auto.noCCseg.mgz -n asen auto.mgz -subjid | aseq.auto.noCCseg.mgz asen auto.mgz |

Done

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