



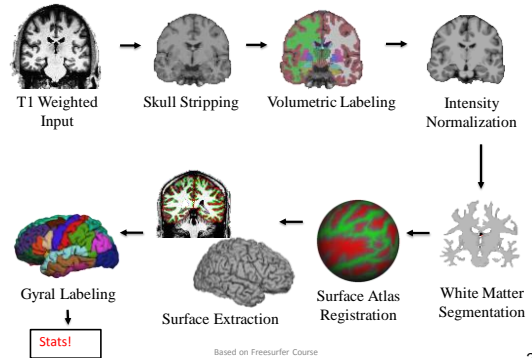
DPABISurf Advanced: More about FreeSurfer

Chao-Gan YAN, Ph.D.
严超赣

yancg@psych.ac.cn
http://rfmri.org
The R-fMRI Lab

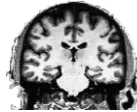
Institute of Psychology, Chinese Academy of Sciences

Processing Stream Overview



Input: T1 Weighted Image

- T1 Contrast: white matter brighter than gray matter
- ~1mm³ (no more than 1.5mm)
- Higher resolution may be worse!
- Full Brain
- Usually one acquisition is ok
- MPRAGE or SPGR
- 1.5T or 3T
- 7T might have problems
- Subject age > 5 years old
- Brain has no major problems (ie, tumors, parts missing)
- Non-human primates possible



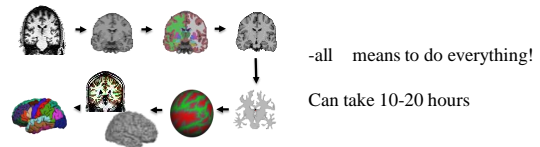
More MRI Pulse Sequence Parameter Details:
<http://www.nmr.mgh.harvard.edu/~andre>

Based on FreeSurfer Course

Fully Automated Reconstruction*

```
recon-all -i file.dcm -subject bert -all
```

* "Reconstruction" here refers to cortical reconstruction, not k-space reconstruction.



Based on FreeSurfer Course

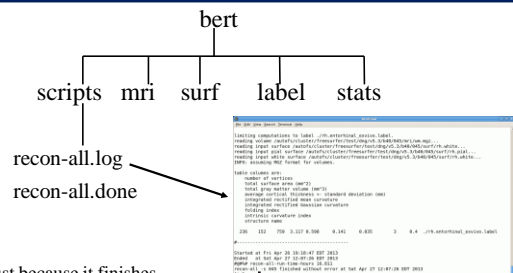
Upon Completion...

```
$SUBJECTS_DIR/bert
├── scripts
├── mri
├── surf
├── label
└── stats
```

```
recon-all -i file.dcm -subject bert -all
```

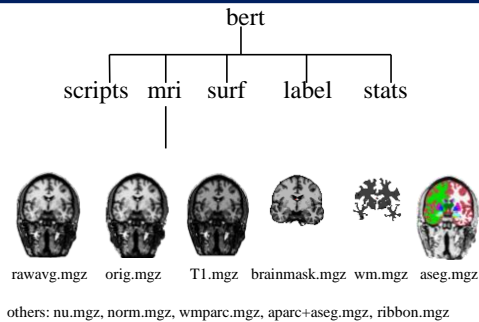
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Upon Completion...



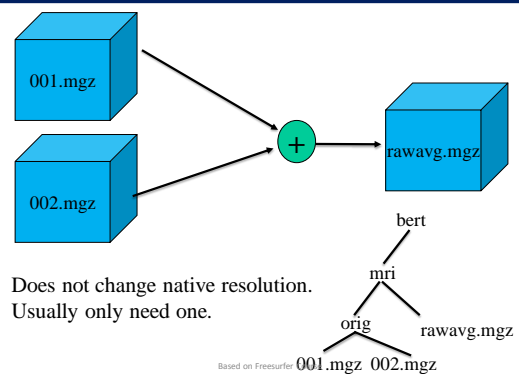
Based on FreeSurfer Course

Upon Completion...



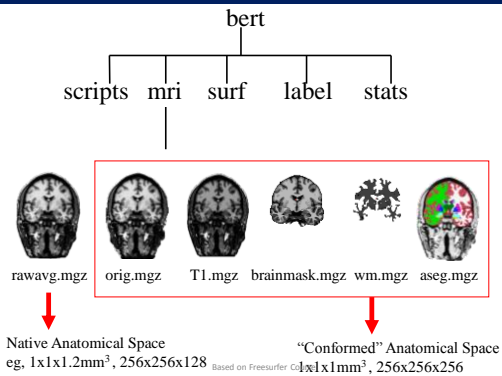
7

Motion Correction and Averaging



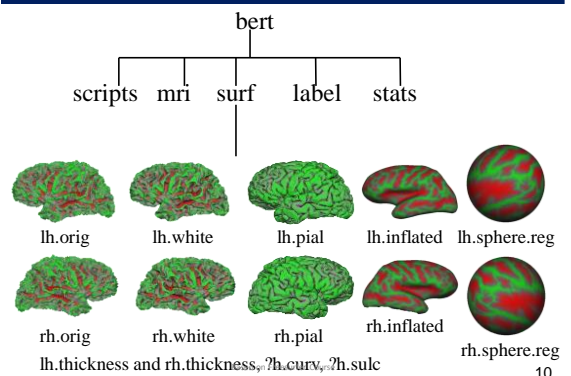
8

Upon Completion...

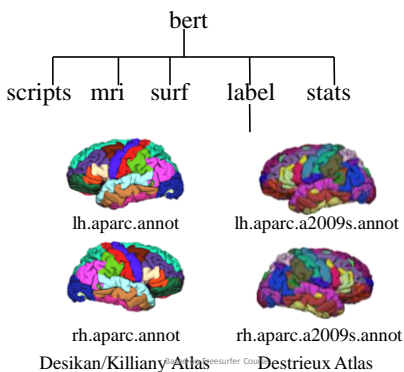


9

Upon Completion...

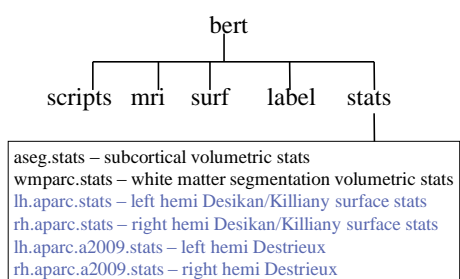


Upon Completion...



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Upon Completion...



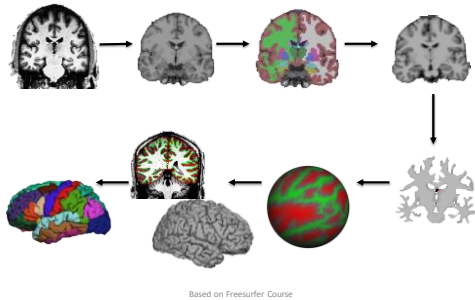
stats files are text files with summary information, eg:
volume of left amygdala
average thickness in superior temporal gyrus

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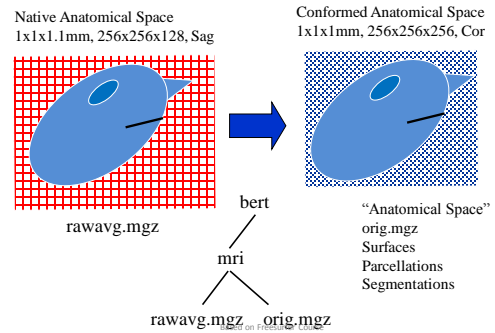
12

Some of the Processing Steps...



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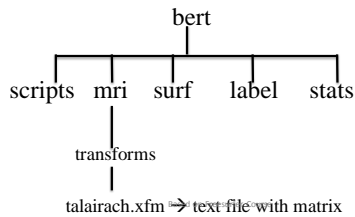
Conform Step



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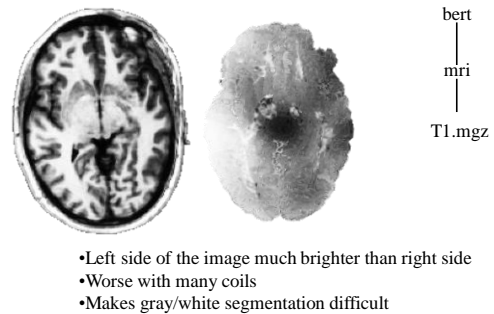
Talairach Transform

- Computes 12 DOF transform matrix
- Does NOT resample to Talairach space!
- MNI305 template
- Mostly used to report coordinates



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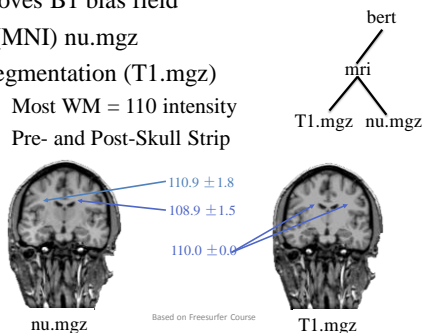
Intensity Bias



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Intensity Normalization

- Removes B1 bias field
- NU (MNI) nu.mgz
- Presegmentation (T1.mgz)
 - Most WM = 110 intensity
 - Pre- and Post-Skull Strip



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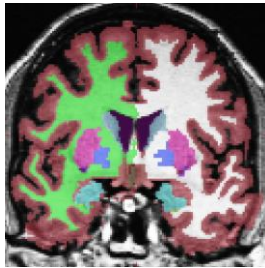
Skull Strip

- Removes all non-brain
 - Skull, Eyes, Neck, Dura
- brainmask.mgz (cf, brain.mgz)



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Automatic Volume Labeling



ASeg Volume

Atlas: \$FREESURFER_HOME/average/RB_all_2008-03-26

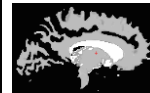
- Used to fill in subcortical structures for creating subcortical mass
- Useful in its own right
- aseg.mgz
- More in ROI Talk

bert
mri
aseg.mgz

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“White Matter” Segmentation

- Separates white matter from everything else
- Uses aseg to “fill in” subcortical structures
- Cerebellum removed, brain stem still there
- wm.mgz -- “wm” not a very good name!



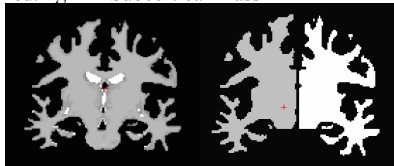
bert
mri
wm.mgz

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Fill and Cut (Subcortical Mass)

- Fills in any holes.
- Removes any islands
- Removes brain stem
- Separates hemispheres (each hemi has different value)
- filled.mgz = “Subcortical Mass”



WM Volume (wm.mgz) Filled Volume (filled.mgz)
Based on Freesurfer (Subcortical Mass)

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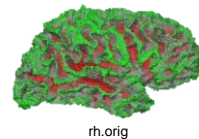
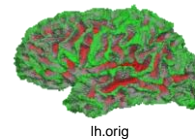
Surface Extraction

- Hemispheres separated
- Fit to wm.mgz
- 1mm resolution
- Rough, jagged



wm.mgz

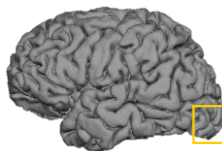
bert
surf
lh.orig
rh.orig



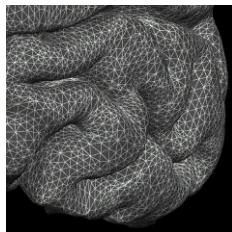
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Surface Model



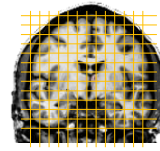
- Mesh (“Finite Element”)
- Vertex = point of triangles
- Neighborhood
- XYZ at each vertex
- Triangles/Faces ~ 300,000
- Vertices ~ 140,000
- Area, Distance
- Curvature, Thickness



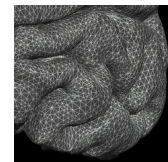
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Volume vs Surface Model



- Volume
- uniform grid
 - voxel is an intersection of grid lines
 - columns, rows, slices
 - voxel size/distance
 - voxel assigned a value
 - XYZ

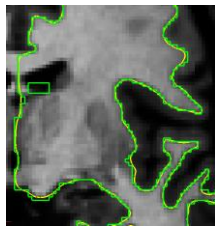


- Surface
- NON-uniform grid
 - vertex is an intersection of triangles
 - each vertex has an index
 - distance between vertices ~1mm
 - vertex assigned a value
 - XYZ

Vector of vertex values (~140,000)

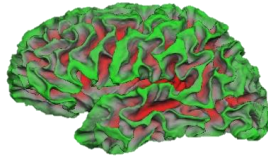
24

White Matter Surface



- Nudge orig surface
- Follow T1 intensity gradients
- Smoothness constraint
- Vertex identity preserved

— orig surface
— white surface

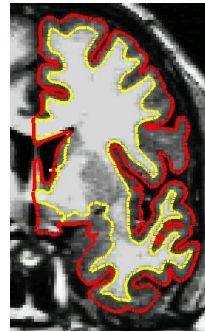


lh.white
rh.white

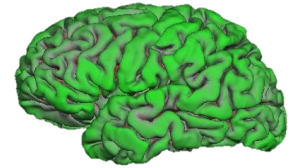
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Pial Surface



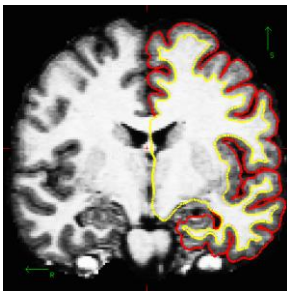
- Nudge white surface
- Follow T1 intensity gradients
- Vertex identity preserved



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Pial surf grows from white surf

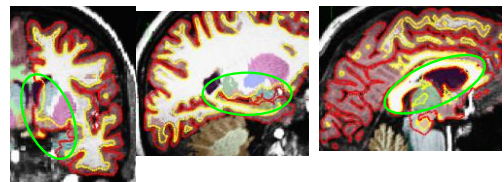


Errors in pial surface placement are typically caused by underlying errors in the white matter placement, and can be corrected by interventions such as white matter control points.

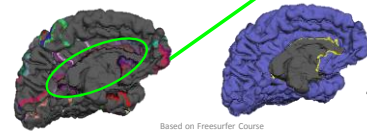
Based on Freesurfer Course

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Non-Cortical Areas of Surface



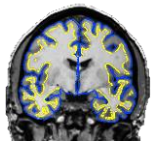
Amygdala, Putamen, Hippocampus, Caudate, Ventricles, CC



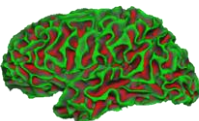
Based on Freesurfer Course

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Inflation: 2D Surface in 3D Space



White Surface



Pial Surface

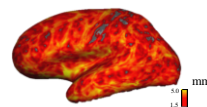
- Nudge vertices
- No intensity constraint
- See inside sulci
- Used for sphere

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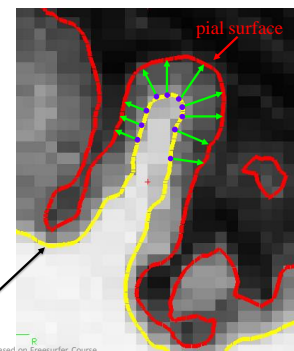
Cortical Thickness

- Distance between white and pial surfaces
- One value per vertex
- Surface-based more accurate than volume-based



"Overlay", "Heat map"

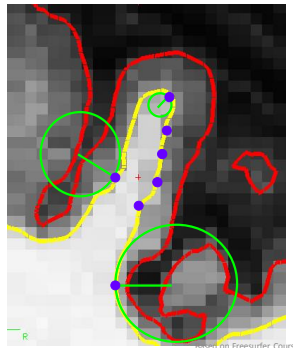
white/gray surface
lh.thickness, rh.thickness



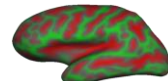
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Curvature (Radial)



- Circle tangent to surface at each vertex
- Curvature measure is 1/radius of circle
- One value per vertex
- Signed (sulcus/gyrus)

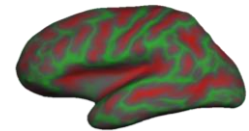
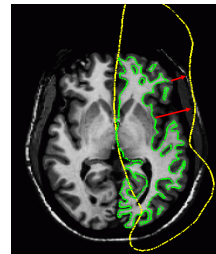


lh.curv, rh.curv

"Overlay", "Red/Green"

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Sulcal Depth



lh.sulc, rh.sulc

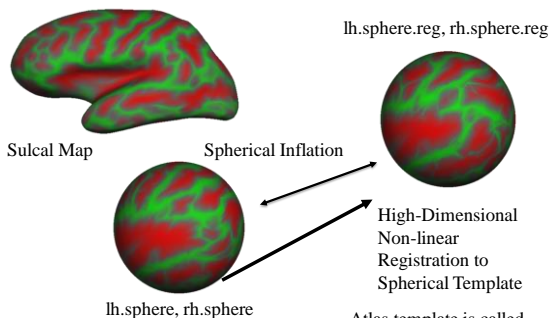


lh.curv, rh.curv

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Spherical Registration

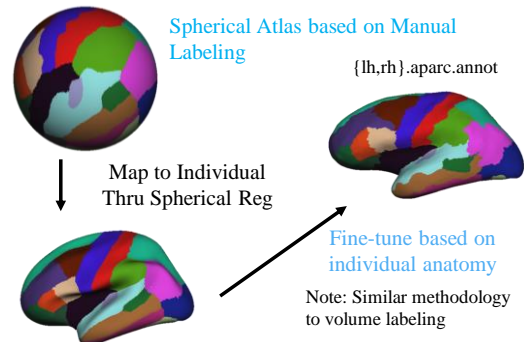


More in surface-based analysis talk.

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Automatic Cortical Parcellation

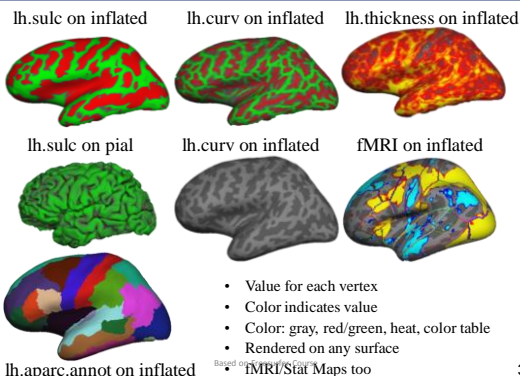


More in the Anatomical ROI talk

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Surface Overlays



- Value for each vertex
- Color indicates value
- Color: gray, red/green, heat, color table
- Rendered on any surface
- fMRI/Stat Maps too

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ROI Summaries:

\$SUBJECTS_DIR/bert/stats
 aseg.stats – volume summaries
 ?h.aparc.stats – desikan/killiany surface summaries
 ?h.aparc.a2009s.stats – destrieux surface summaries
 wmparc.stats – white matter parcellation

Index	SegId	NVoxels	Volume_mm3	StructName	normMean	normStdDev	normMin	normMax	normRange
1	1	0	0.0	Left-Cerebral-Exterior	0.0000	0.0000	0.0000	0.0000	0.0000
2	2	265295	265295.0	Left-Cerebral-White-Matter	106.6763	8.3842	35.0000	169.0000	134.0000
3	3	251540	251540.0	Left-Cerebral-Cortex	81.8395	10.2448	29.0000	170.0000	141.0000
4	4	7347	7347.0	Left-Lateral-Ventricle	42.5800	12.7435	21.0000	90.0000	69.0000
5	5	431	431.0	Left-Inf-Lat-Vent	66.2805	11.4191	30.0000	95.0000	65.0000
6	6	0	0.0	Left-Cerebellum-Exterior	0.0000	0.0000	0.0000	0.0000	0.0000

Routines to generate spread sheets of group data

- asegstats2table --help
- aparcstats2table --help

More info in Anatomical ROI talk

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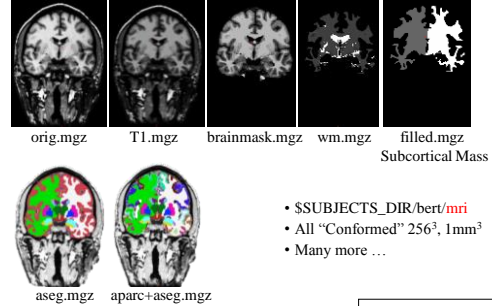
Results

- Volumes
- Surfaces
- Surface Overlays
- ROI Summaries

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Volumes



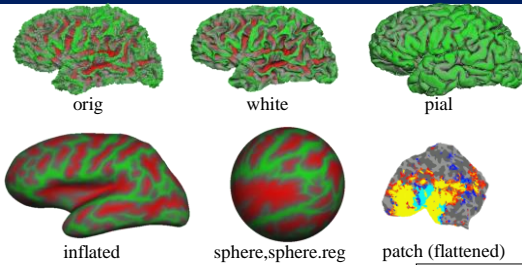
- `$$SUBJECTS_DIR/bert/mri`
- All “Conformed” 256³, 1mm³
- Many more ...

Volume Viewer:
tkmedit

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Surfaces

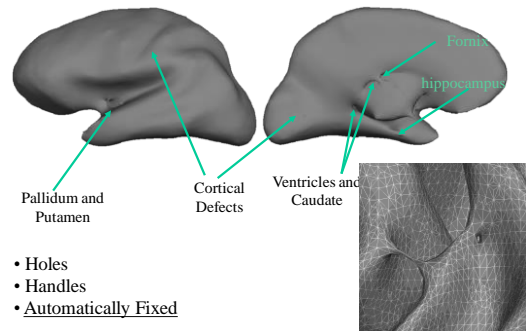


Surface Viewer:
tksurfer

- `$$SUBJECTS_DIR/bert/surf`
- Number/Identity of vertices stays the same (except patches)
- XYZ Location Changes
- Flattening not done as part of standard reconstruction

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Topological Defects

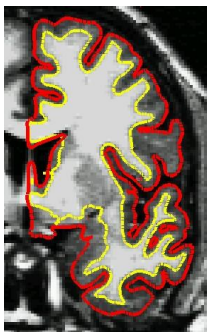


- Holes
- Handles
- Automatically Fixed

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Find “Subcortical Mass”

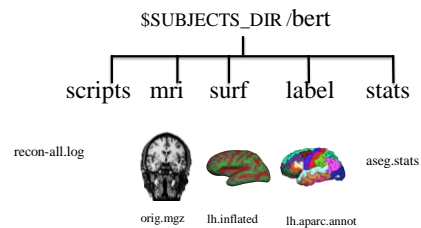


- All White Matter
- All Subcortical Structures
- Ventricles
- Excludes brain stem and cerebellum
- Hemispheres separated
- Connected (no islands)
- Many Stages ... More Later ...

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Overview



`recon-all -i file.dcm -subject bert -all`

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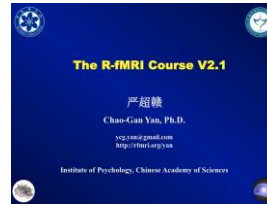
Surface Reconstruction Overview

- Input: T1-weighted (MPRAGE,SPGR)
- Find white/gray surface
- Find pial surface
- “Find” = create mesh
 - Vertices, neighbors, triangles, coordinates
 - Accurately follows boundaries between tissue types
 - “Topologically Correct”
 - closed surface, no donut holes
 - no self-intersections
- Generate surface-based cross-subject registration
- Label cortical folding patterns
- Subcortical Segmentation along the way

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Further Help



<http://rfmri.org/Course>



<http://rfmri.org/wiki>



The R-fMRI Journal Club



Official Account: RFMRILab

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DPABI特训营与DPABISurf加强营



**第六届DPABI/DPARSF特训营
暨DPABISurf加强营通知
中国·北京 2019.10.26~10.28**

定期举办，请关注<http://rfmri.org>

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深度特训与数据分析



静息态功能磁共振成像数据处理深度特训

从您见到这条消息开始，您便将有机会与 The R-fMRI Lab 的静息态功能磁共振专家团队共同探索大脑的奥秘！深度跟组特训期间，您将会亲身体验：

- 数据处理 专家指导下高效学习静态功能磁共振成像数据处理
- 思路设计 与国际知名专家讨论形成研究思路
- 论文撰写 系统的 SCI 论文写作训练



静息态功能磁共振成像深度数据分析

<http://deepbrain.com>

功能磁共振成像越来越成为一种主流的科研手段,然而功能磁共振的数据分析却是一项具有高度挑战性的工作。海量的原始数据,繁多的分析步骤,复杂的分析方法都让研究者们无所适从。恰当的分析方法可以从普通的数据中挖掘出富有创新性的结果,而不适当的分析则可能让精心收集的数据黯然失色。深度大脑公司联合 The R-MRI Lab 的专业功能磁共振成像团队推出一站式功能磁共振数据分析解决方案,助力从原始功能磁共振数据得到的结果。

DPABISurf工作站

DPABI工作站

序号	名称	参数	市场指导价
1.	DPAB标准工作站 (Windows)	14英寸宽屏笔记本电脑, 固态硬盘, 固态硬盘	
2.	DPAB标准工作站 (Linux)	14英寸屏/超薄屏+4200L, 16C内存, 256G固态硬盘+1T固态硬盘, PCIe, 独立显卡, 固态硬盘	¥8999
3.	DPAB标准工作站	标准配置	
4.	Linux/Windows	20880颗流明亮度背光屏13.4英寸 2.8K分辨率 2160P, 16C 512G ROM, 4GDDR5, 2666MHz, 7.9 4.7英寸 2.8K 分辨率, 2160P, 2000 流 明, 4K, 10bit, 4K30, 2000 流明, 2000 流 明, 4K30, 2000 流明, 2000 流明	¥5999
5.	DPAB Computational Core	16.8英寸超窄边框显示屏 15.6英寸超窄边框显示屏	
6.	DPAB标准工作站 (Windows)	16英寸十二代7-8750H, 16C内存, 256G固态硬盘+1T固态硬盘, ¥9900 固态硬盘	¥24999
7.	DPAB Mobile Windows		

5	DPA8181工作主机 (Mac)	Mac Pro	
6	DPA8181工作主机 (Core Mac)	12英寸Mac mini M1 Max M1 处理器, 256GB Turbo Boost 最高可达 4.3GHz, 64GB的 Unified Memory DDR4-3200, 178 瓦时容量, Radeon Pro Vega 56 图形处理器 8GB HBM2 显存	¥4699
7	DPA8181工作主机 (Mac)	13英寸 MacBook Pro 1.4GHz 四核 Intel Core i7 处理器, Turbo Boost 最高可达 4.3GHz, 16GB内存 240GB SSD, 5120 万像素, Radeon Pro 5400 显卡 8GB HBM2 显存, 45W 功耗, 支持 雷电3接口, 支持 USB-C 充电, 支持 Apple Watch 磁力充电线圈和显示屏, 摄像头支持 4K 视频, 3 个 USB-C 接口	¥3299
8	DPA8181工作主机 (Core Mac)	如需要更有竞争力的价格, 请购买更强大的性能, 性价比更高的产品	定制

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DPABI计算工作站

2.	DPABI计算工作站	塔式服务器	
	(Linux/Windows)	20核40线程英特尔至强E5-2680 v4 2.2G *2, 9.6CT/s ZUP, 14M, Turbo, HT(BSW), 4*16GB DDR4, 64G内存, 2666MT/s, 4*4TB 7.2K RPM NLAS, 16TB硬盘, 冗余电 源, RAID卡: H130, DVD-RW 联电 三年服务	¥59999



<http://deepbrain.com/DPABICore>

DPABISurf 并行计算:

每天完成 **20** 个被试的皮层计算!!!

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The R-fMRI Lab



 WeChat Official Account: RFMRILab

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Thanks for your attention!