Processing Pipeline for Fetal Brain MRI

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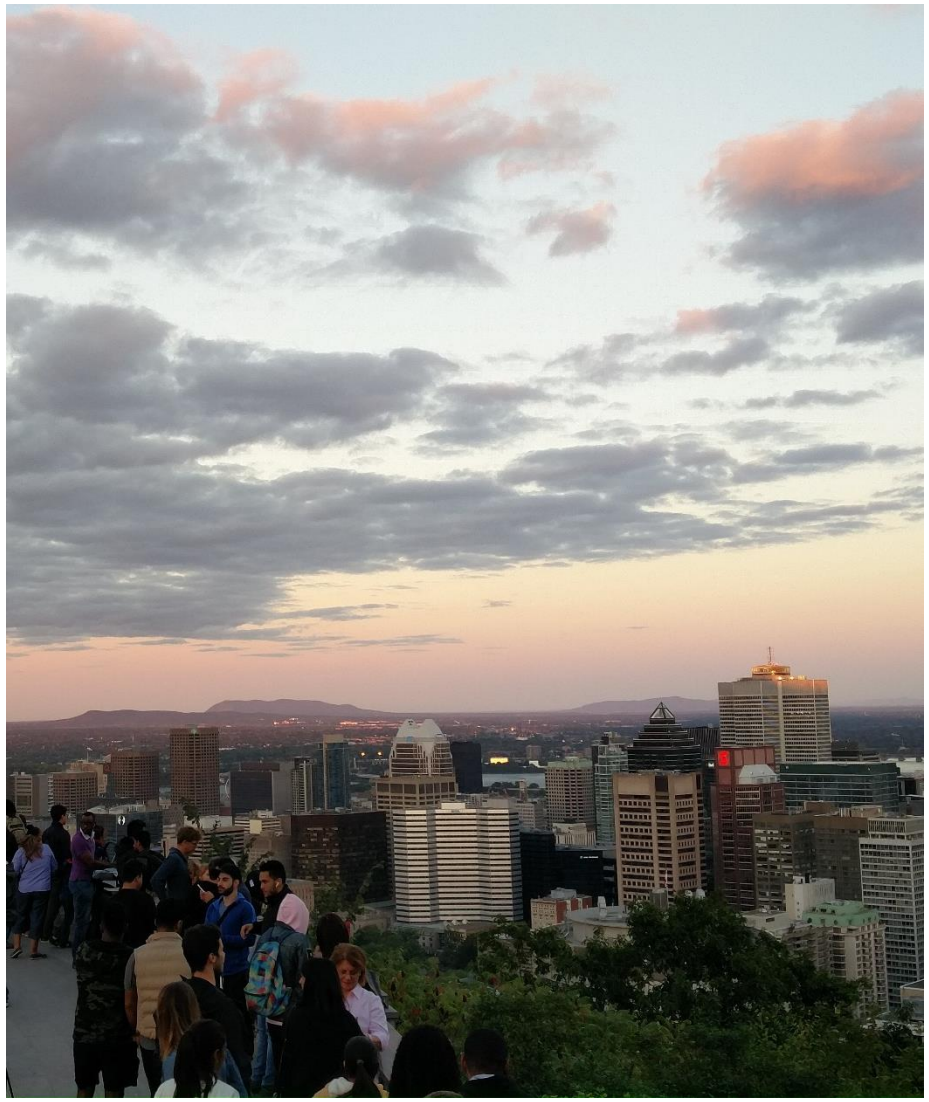
neuro



About Me

- First year undergraduate exchange student
- Computer Science/Biology combined major

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The N.U.in Program

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École d'éducation permanente

2016 Paper

ORIGINAL RESEARCH ARTICLE

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Quantitative and Qualitative Analysis of Transient Fetal Compartments during Prenatal Human Brain Development

Lana Vasung[1,2*], Claude Lepage[3], Milan Radoš[1], Mihovil Pletikos[1,4], Jennifer S. Goldman[3], Jonas Richiardi[5], Marina Raguž[1], Elda Fischi-Gómez[2], Sherif Karama[3], Petra S. Huppi[2], Alan C. Evans[3†] and Ivica Kostovic[1†]

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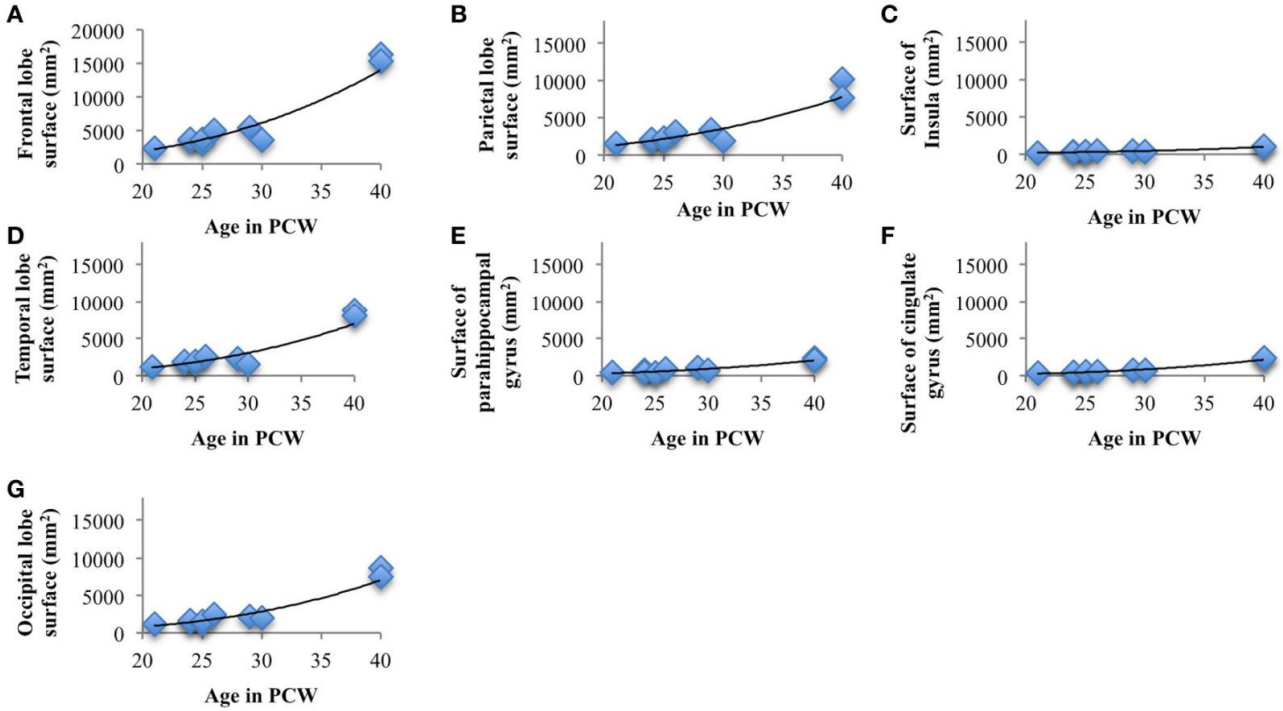
The cerebral wall of the human fetal brain is composed of transient cellular compartments, which show characteristic spatiotemporal relationships with intensity of major neurogenic events (cell proliferation, migration, axonal growth, dendritic differentiation, synaptogenesis, cell death, and myelination). The aim of the present study was to obtain new quantitative data describing volume, surface area, and thickness of transient compartments in the human fetal cerebrum. Forty-four postmortem fetal brains aged 13–40 postconceptional weeks (PCW) were included in this study. High-



Vasung L, Lepage C, Radoš M, et al. Quantitative and Qualitative Analysis of Transient Fetal Compartments during Prenatal Human Brain Development. *Front Neuroanat*. 2016;10:11. Published 2016 Feb 24. doi:10.3389/fnana.2016.00011

Project Goals

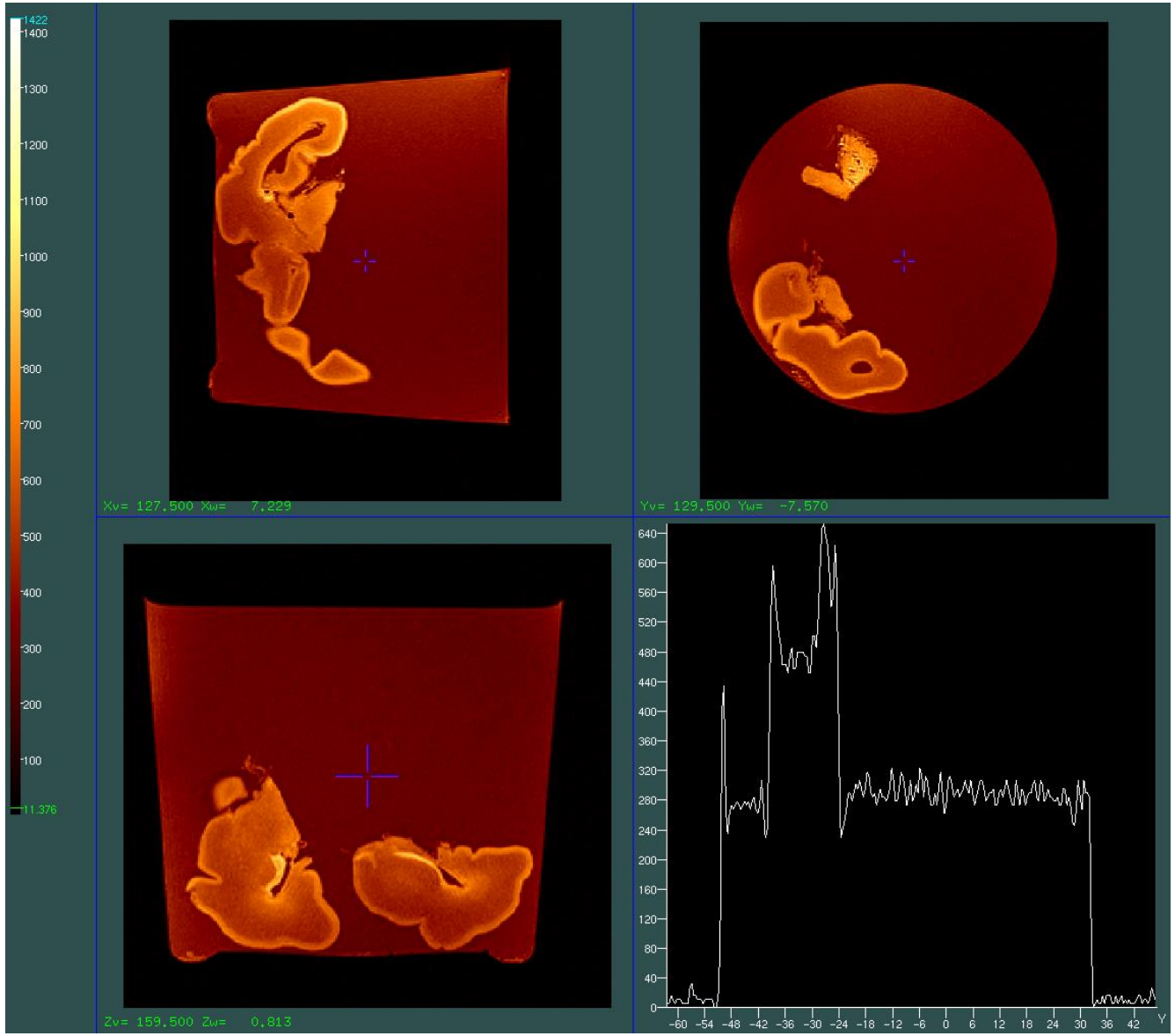
Fundamental question of ~~computer~~ science:

How can we *quantify* the natural world?

- Surface area
- Volume

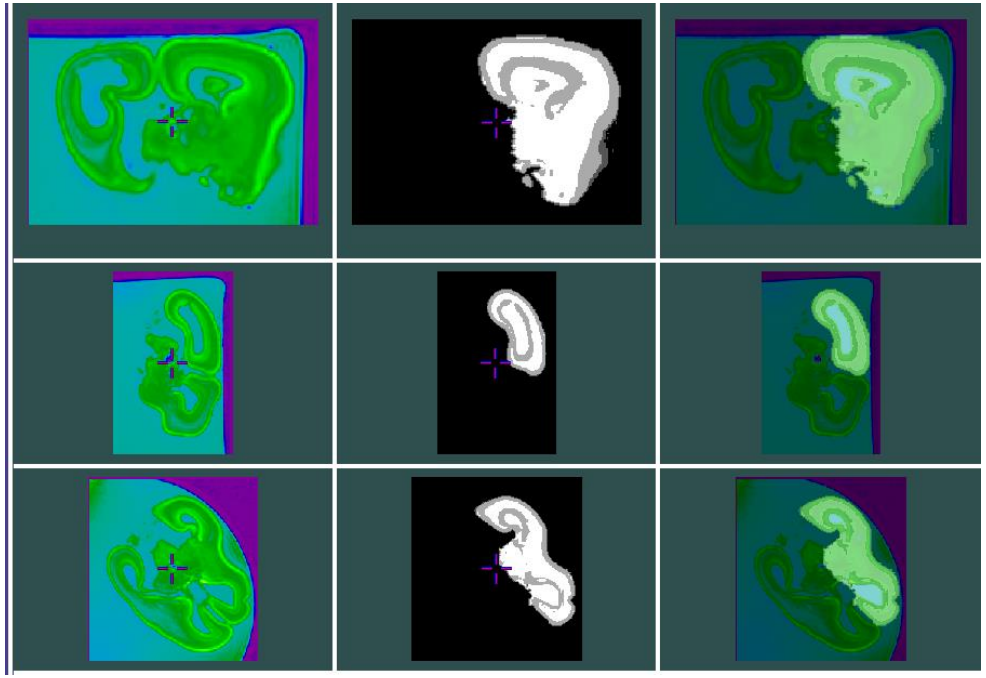
(of the individual brain regions)

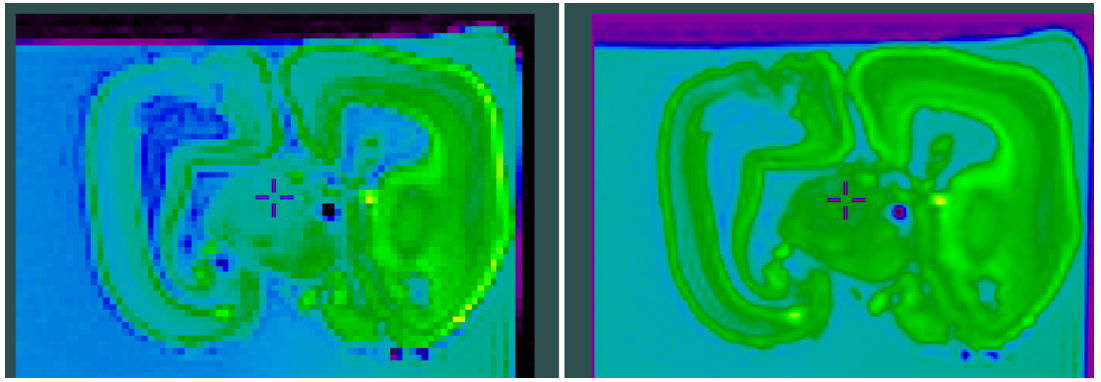
- Gyrification index



Fetal Brain Image Processing Pipeline

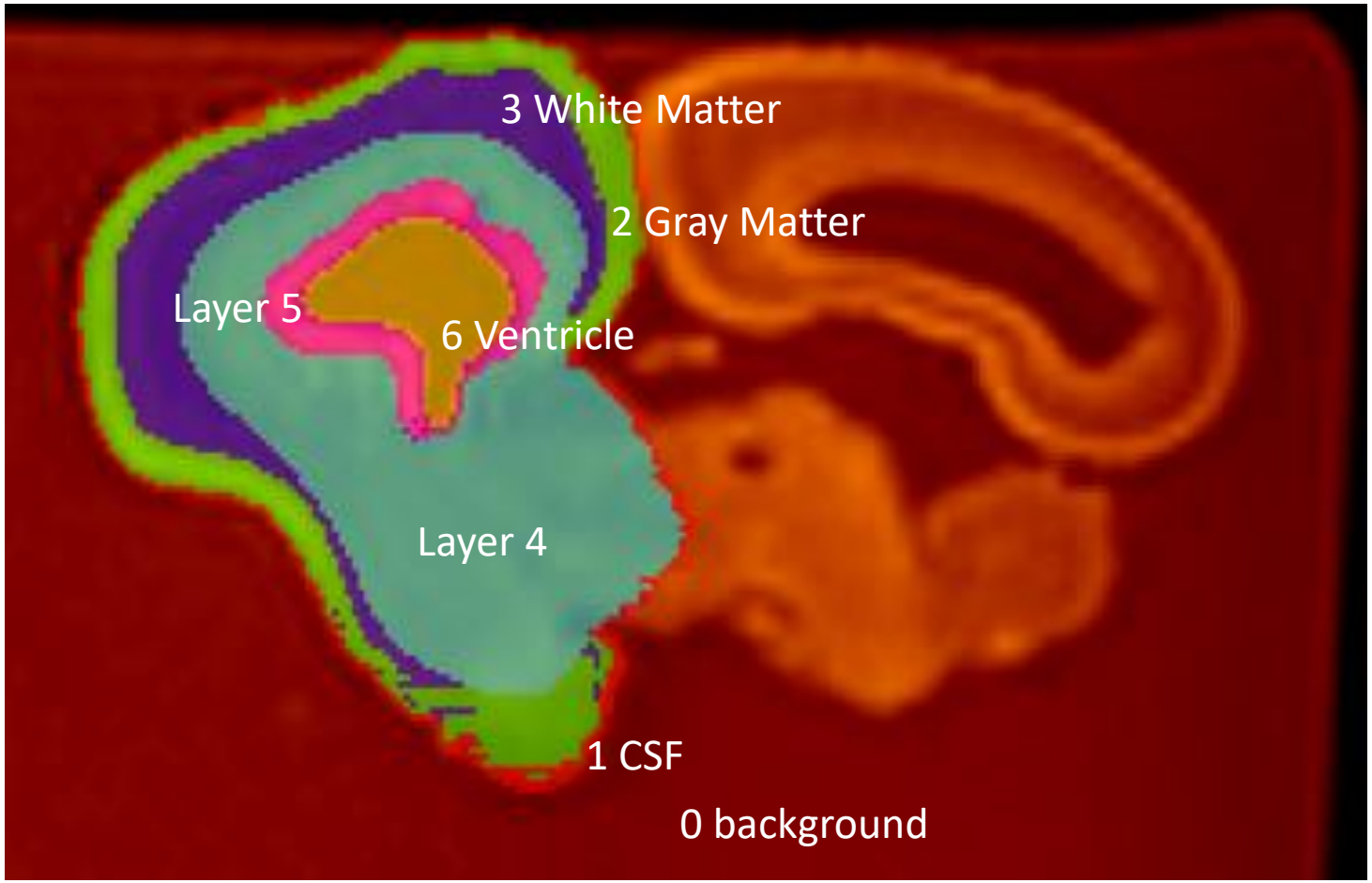
(Semi-)Automated volumetric analysis of brains





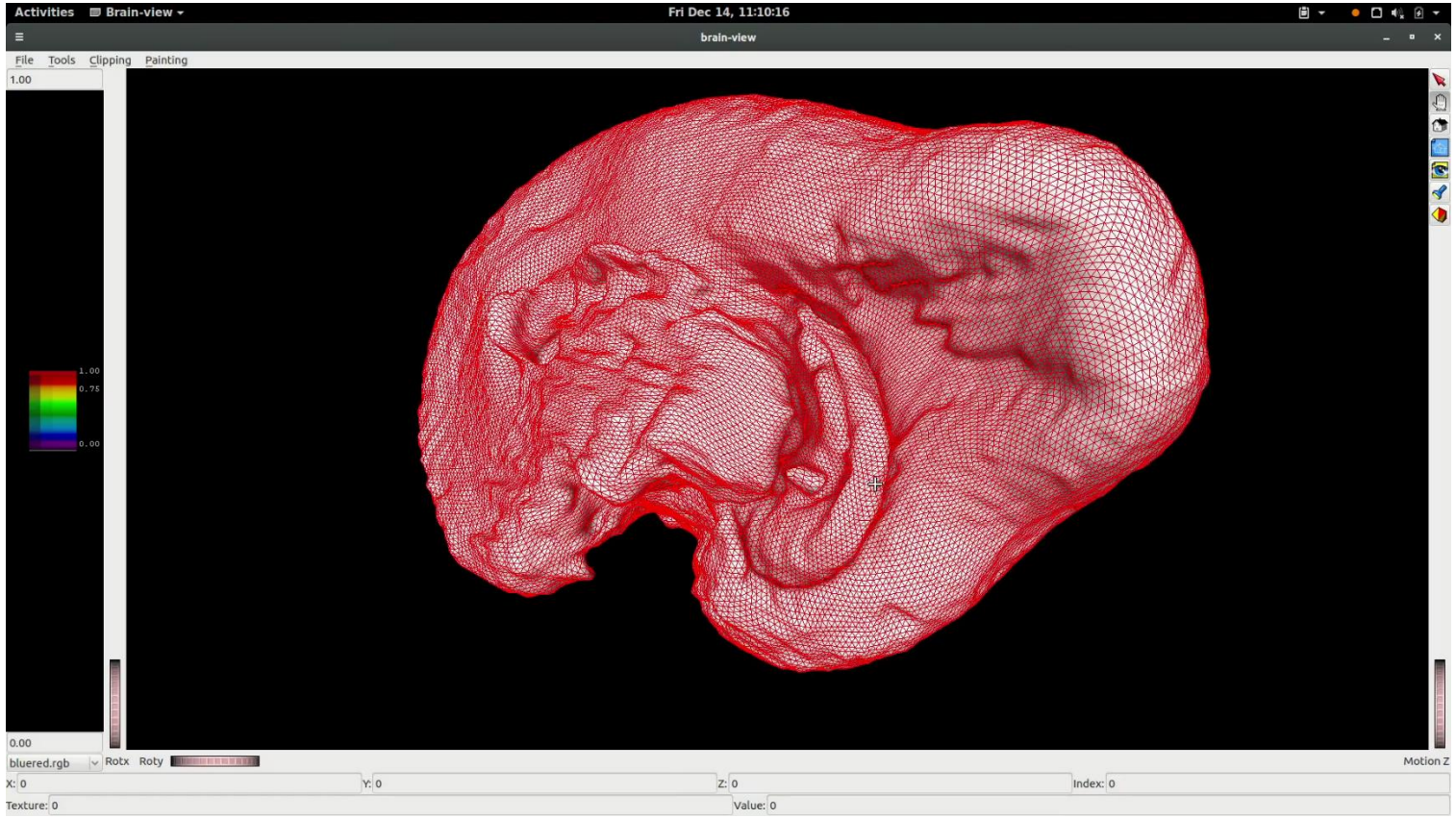
```
jzhang@ace-ws-84: ~/ace_mount/ace_home/FetalPipeline
File  Edit  View  Search  Terminal  Help
jzhang@ace-ws-84:~/ace_mount/ace_home/FetalPipeline$ ls ukf_cfpxy_20wk_t1/LEFT/
area.dat                    surf_kk600.obj          thickness_layer4_10mm.txt
basal_ganglia.mnc           surf_kk800.obj          thickness_layer5_10mm.txt
bo.obj                      surf_pre_smoothing.obj  thickness_layer6_10mm.txt
csf_only.mnc                t1_cls_correct.mnc      ukf_cfpxy_20wk_t1.mnc
fetus_bg.tag                t1_cls.mnc              ukf_cfpxy_20wk_t1_Sulcus_left.mnc
fetus.tag                   t1_mask.mnc             ukf_cfpxy_t1.xfm
final_cls.mnc               t1_nuc.imp              volumes.dat
gi.dat                      t1_nuc.mnc              white_81920.obj
job                         t1_pve_csf.mnc          white_layer4_81920.obj
mask_final_csf_painted.mnc  t1_pve_disc.mnc         white_layer5_81920.obj
old-surfaces                t1_pve_gm.mnc           white_layer5_mask.mnc
painted_labels_rsl.mnc      t1_pve_wm.mnc           white_surf_sm.obj
paint_labels_left.mnc       t1_regular.mnc          wtags.mnc
surf_kk200.obj              t1_rsl.mnc
surf_kk400.obj              thickness_10mm.txt
jzhang@ace-ws-84:~/ace_mount/ace_home/FetalPipeline$ ls ukf_cf588_15wk_t1/LEFT/
classify  inputs  job  mask  old  old-surfaces  outputs  surfaces  t1_weighted  thickness  transforms
jzhang@ace-ws-84:~/ace_mount/ace_home/FetalPipeline$
```

Tissue Classification



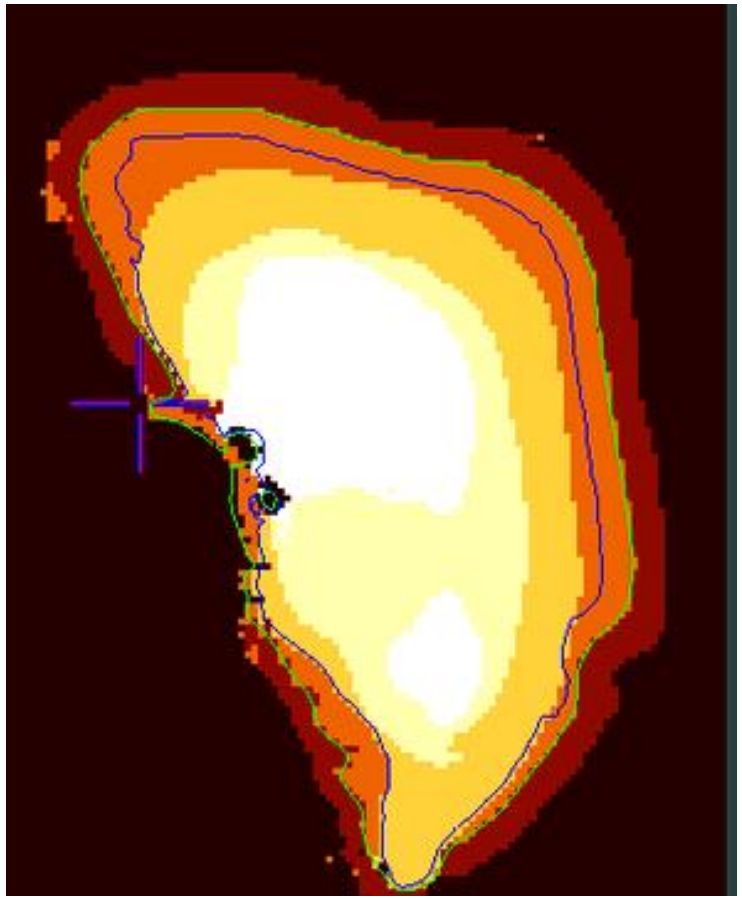
Transient Fetal Sublayers

Marching Cubes for White Surface



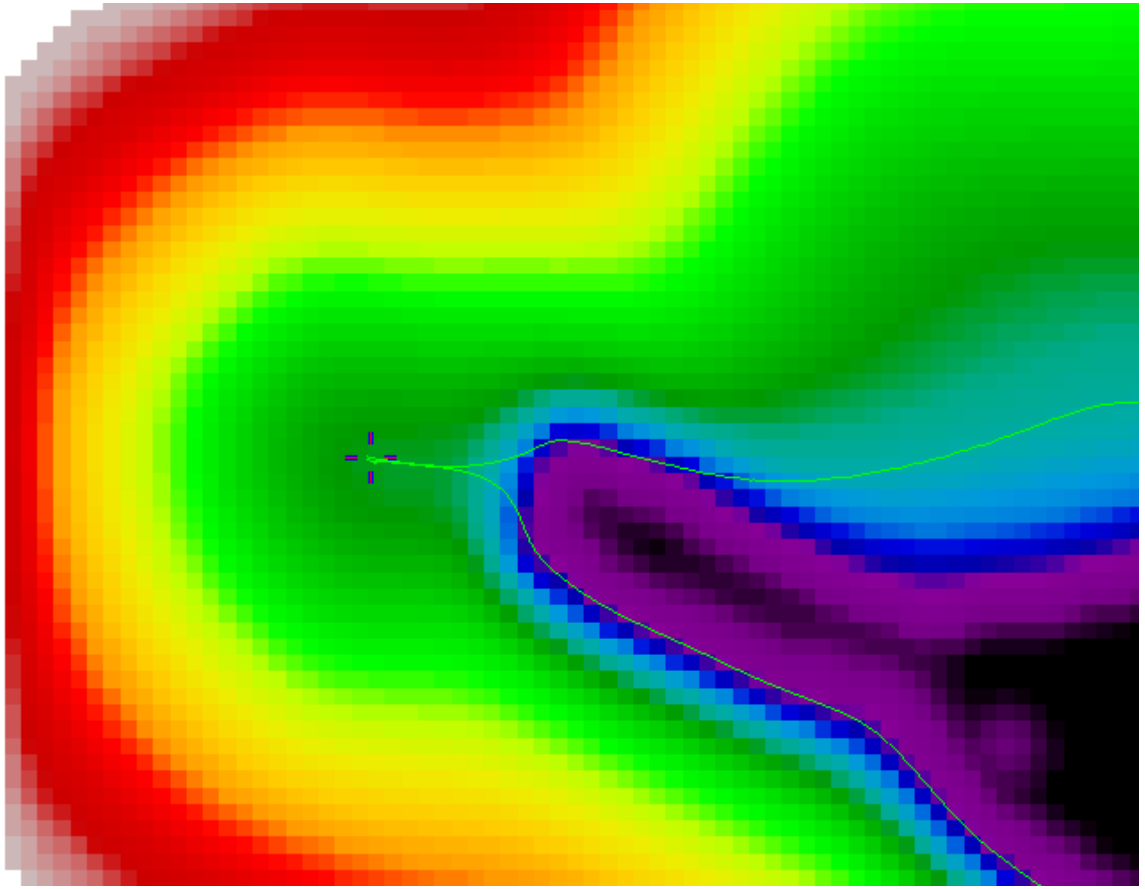
https://youtu.be/U1geauZlpqA

Surface Fitting Parameters

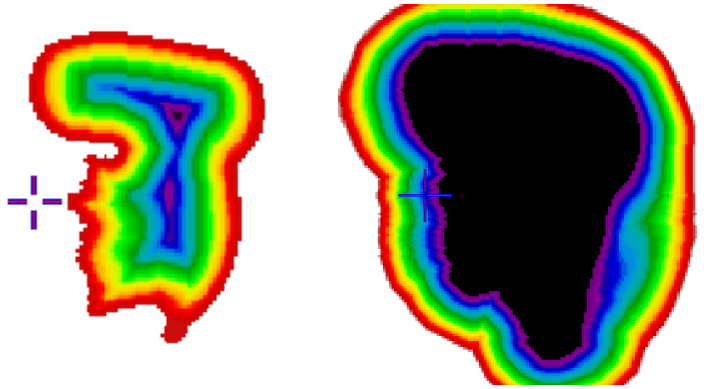


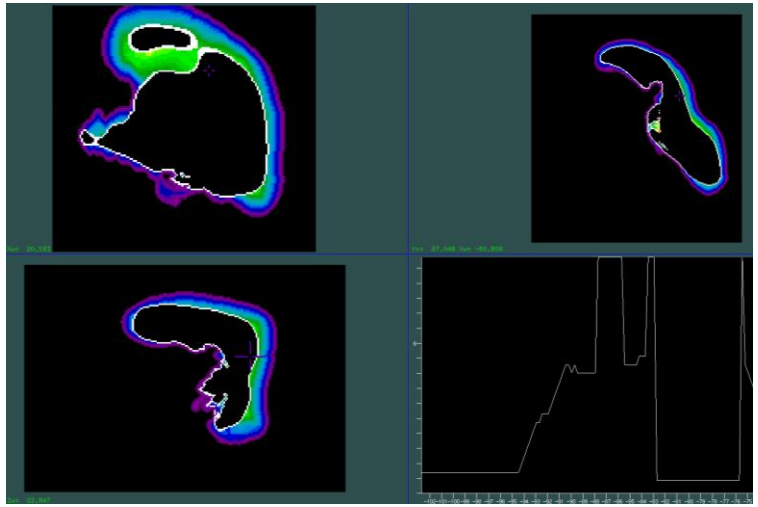
Factor	Parameters
Self-intersection	Weight, distance constraint
Mesh smoothing	Weight
Boundary fitting	Weight, sampling
Step	Size, number of iterations

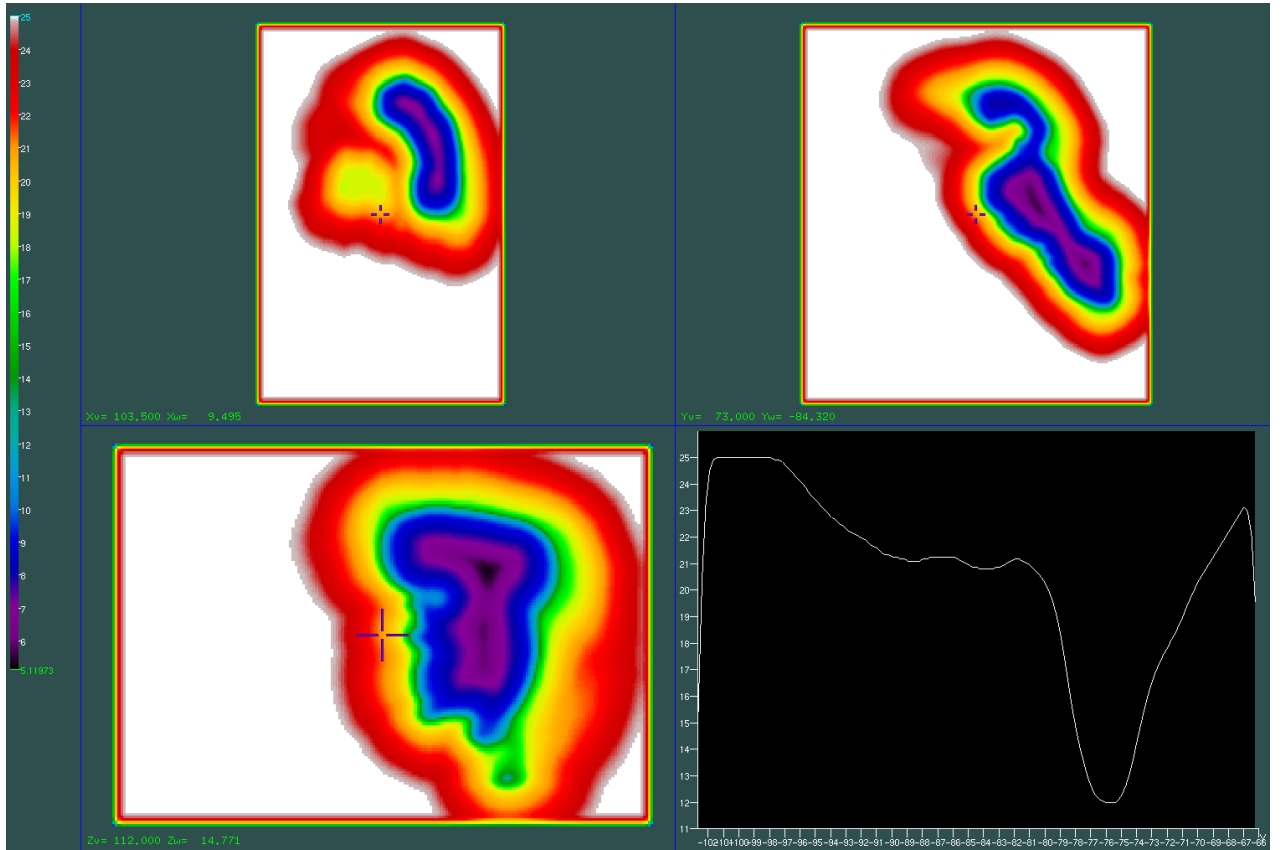
Chamfer Distance Map



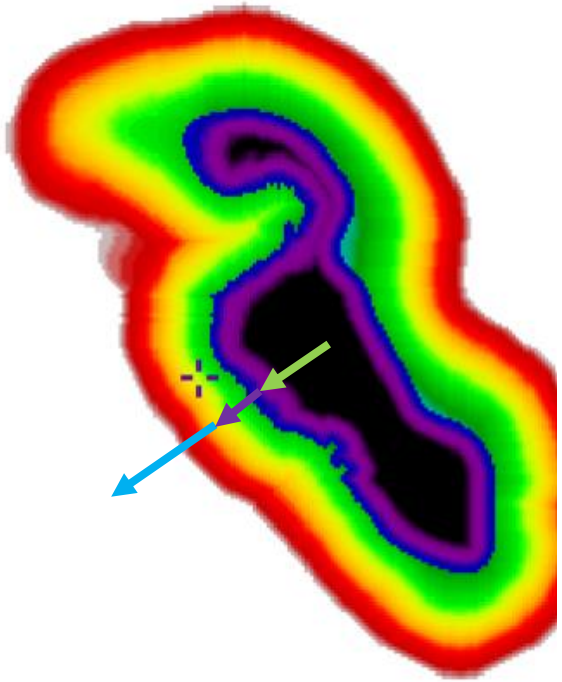
Combined Chamfer Map

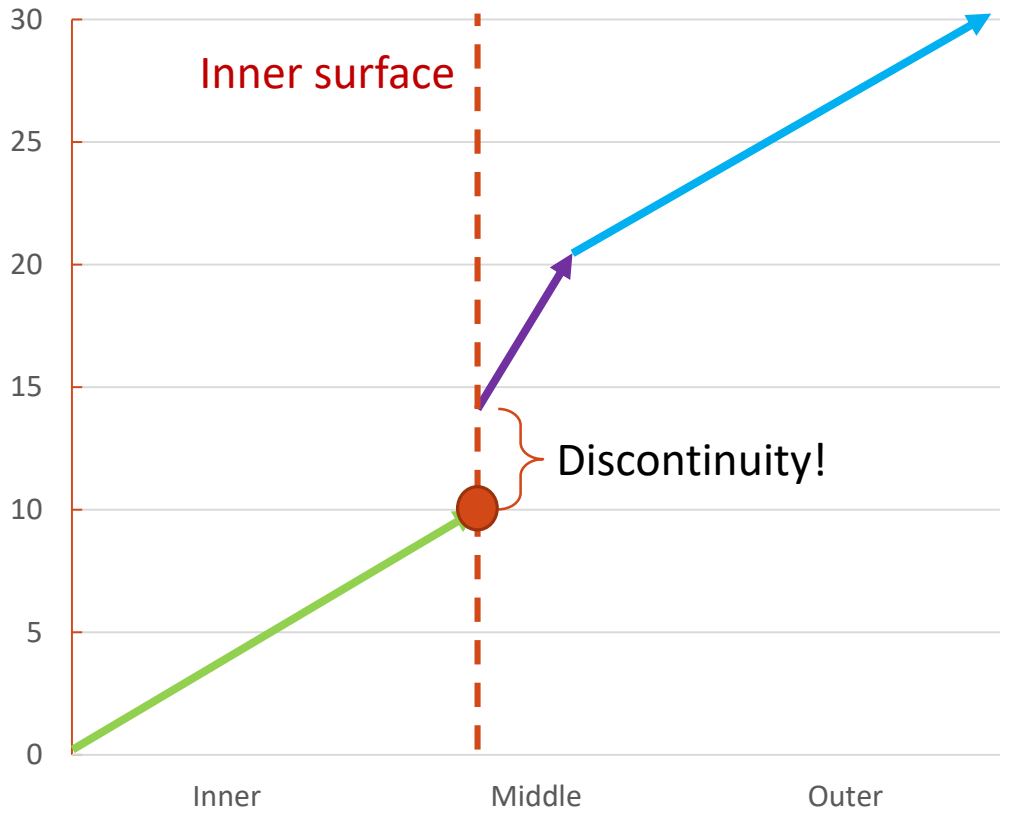




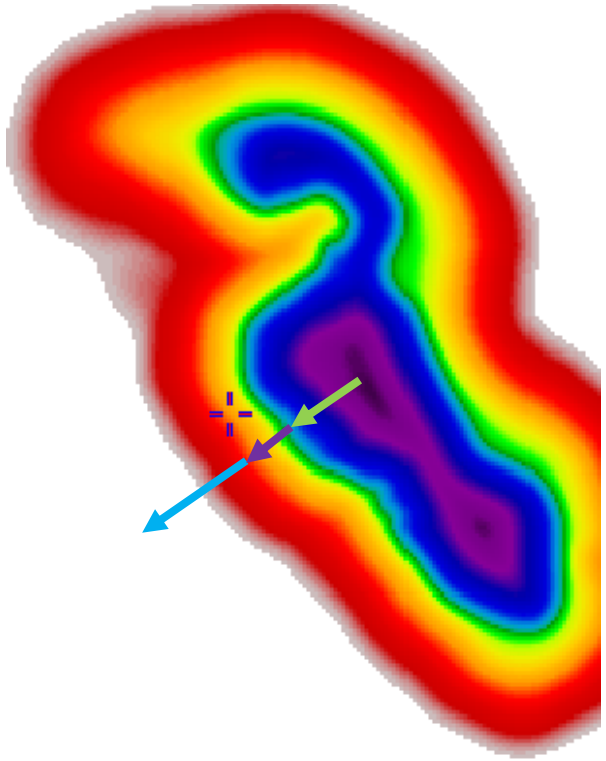


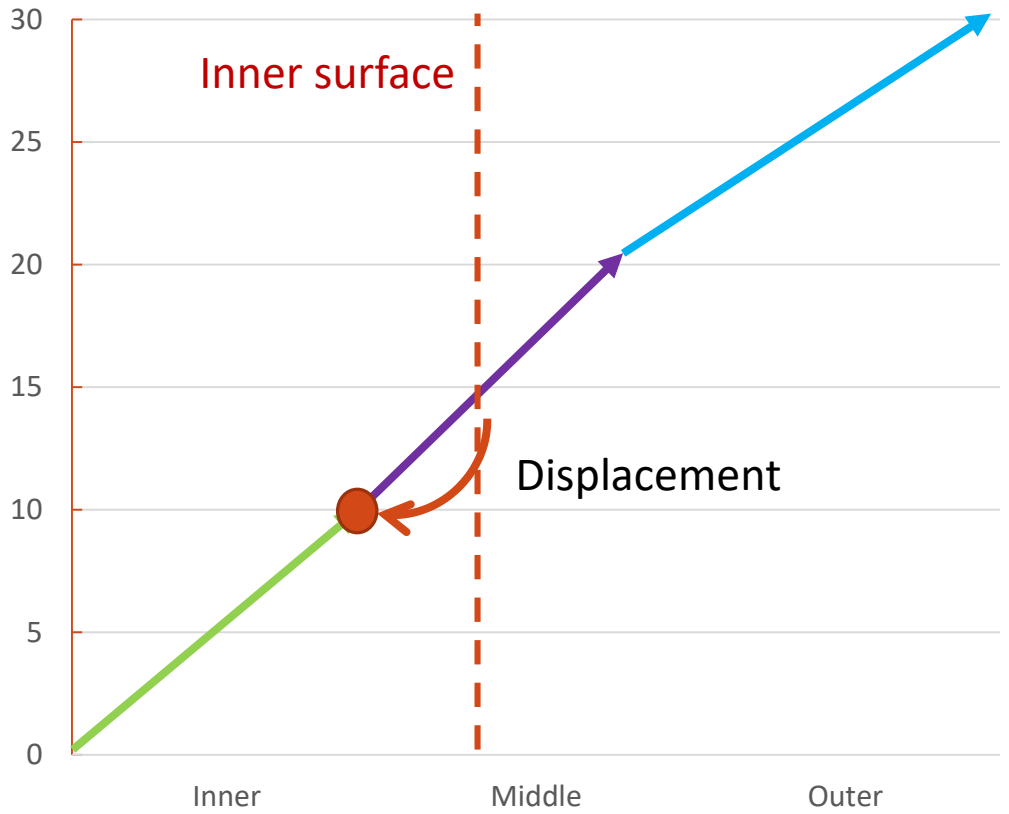
Gradient Slope Kink





Blurring




30
25
20
15
10
5
0
Inner surface
Displacement
Inner
Middle
Outer

Blurring with mincmorph

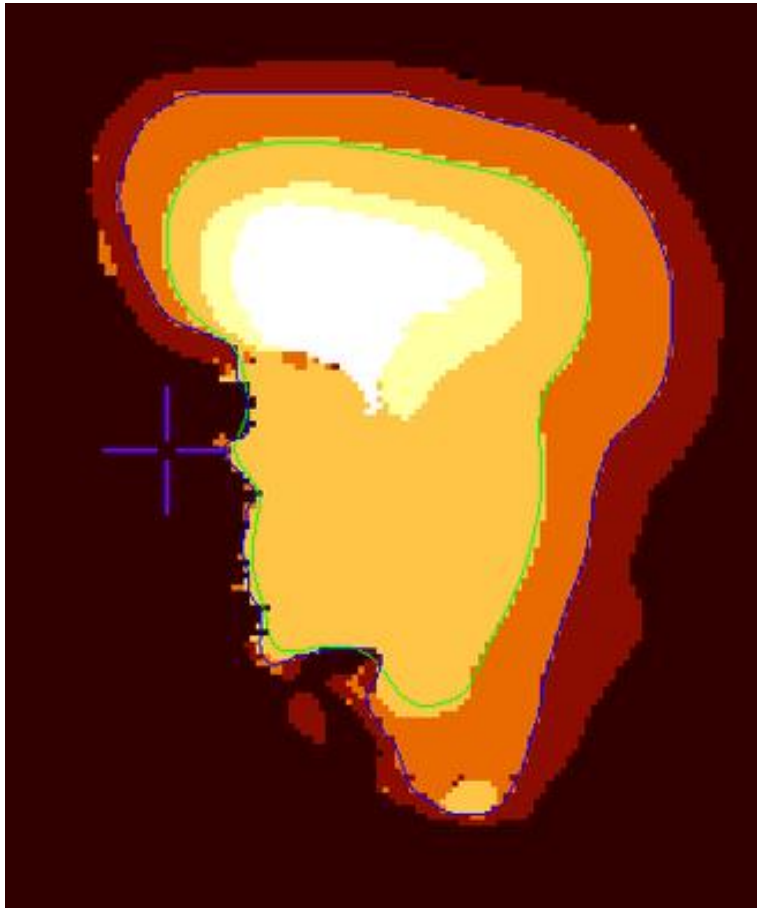
1. Treat blurring of Laplacian field as a heat diffusion problem.

$$\frac{\partial \varphi}{\partial t} = k\nabla^2 \varphi$$

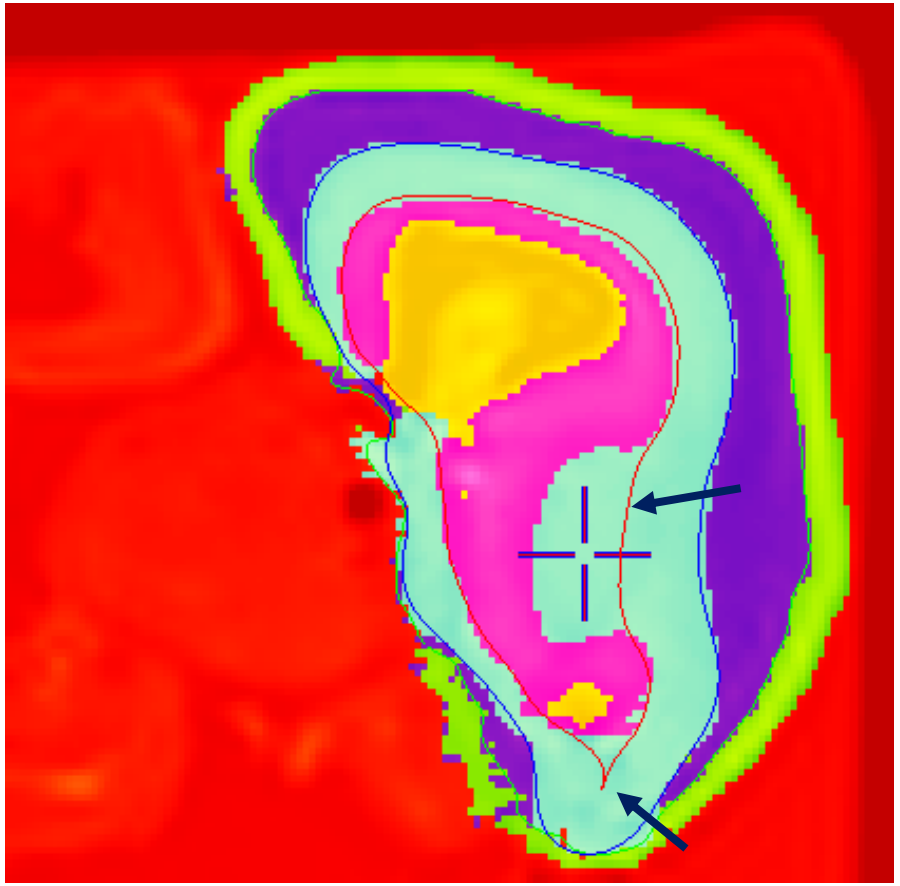
2. Hold the inner chamfer intensity constant

3. Repeat *i=25* iterations?

Last pass of fitting to the original and accurate chamfer map



Future Work



- Scale parameters based on age
- Fix surface_fit vertex distribution
- Layer 4 → layer 5 is challenging
  - Large distance
  - Different shape
- Hybrid chamfer map?

Thank you!

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