Cortex Based Alignment

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CBA is used in for mapping the ROIs defined in Glasser et al. (2016) to individual anatomical volumes. These will be used as regions of interest in further analysis.

The starting point is WM-GM segmentations for each hemisphere separately.

1. Create mid gray matter volumes
   - Go to Volumes -> Cortical Thickness Measurement
   - In the Measurement tab press `Go`
   - In the Mid-GM Volume tab press Create `Volume`
2. Create a Mesh from the Mid-GM vmr.
   - In the Meshes tab press `Create Mesh`
   - from the Tools bar on the right press `Advanced Mesh Smoothing`
3. Reduce the number of vertices.
   - Go to Meshes -> Mesh Simplification
   - Enter the number of vertices and press `Go`
   - For my anatomical volumes 200k was creating resulting in "holes" in the VOIs so I'm using 300k now.
   - You can verify that it worked correctly from in the white text at the bottom.
4. Prepare the surface maps for alignment.
   - Go to Meshes -> Cortex-Based Alignment
   - Select `High resolution` and press `Curvature` and then `Smooth`
   - Go to the next tab `Make Sphere` and press `Morph`
   - After that press `Correct`. You need to do this step to save the sphere.
   - You might need to play around with the values a bit (if you do too little you might not get a good mapping later and if you do too much you will see the golden curvature regions looking strange). I only had to change the default values for one subject.
   - Now go to the tab `Sample Sphere` and press `Map Std Sphere`
   - Make sure you have the correct sphere loaded at the left of the button.
   - After saving hte sphere-to-sphere map load the loaded mesh. Its name ends with *D300k.srf* in case you have reduced the number of vertices to 300k.
   - Then press `Set Std Sphere Vertices`.
   - Depending on how many subjects you have you should now specify the curvature smoothing levels. If you have many subjects you reduce the smoothing and if you have few subjects you increase the smoothing. The default smoothing values did not give good results for me so I use 35-50-65-85 for aligning 6 subjects. I did not test many other values because this already gave a decent result.

- Now press `Source Curvature` and save the curvature surface map file.
- Repeat this for all subjects and all hemispheres.

5. Align the curvature maps
   - Go to Meshes -> Cortex-Based Alignment -> Align Group
   - Add all curvature surface maps that you created for the hemisphere.
   - Select `Align to dynamic group average` and press `Go` and then `Continue`
   - In case you suspect that the volumes look very differently you can perform `Align Rigid` first.
6. Compute Group Average
   - Go to Meshes -> Cortex-Based Alignment -> Options: Select `Shape` below
   - Add all the group aligned curvature meshes. These are the mapped curvature spheres to the standard sphere and the sphere-to-sphere maps that are produced from the previous group alignment step.
   - After averaging perform an additional smoothing by going to Mesh -> Advanced Mesh Smoothing and press `Go`.
   - It is advisable to increase the number of iterations. I use around 1000-1500. Don't forget to save it.
7. Create Curvature Surface Map for the Group Average
   - Load the group averaged surface and go to Meshes -> Cortex-Based Alignment
   - Select `High resolution` in the Curvature tab and press `Curvature` then `Smooth`.
   - After that go the Make Sphere tab press `Morph` and then reduce the NrOfSteps (e.g. 10 steps) and then `Correct`.
   - Note that if you perform too much distortion correction in this step you will likely create new distortions.
   - Now go to the Sample Sphere tab, press `Map Std Sphere` and save the mapping.
   - Load the folded mesh and press `Set Std Sphere Vertices`
   - Choose the appropriate curvature smooth levels (for me 35-50-65-80) and press `Source Curvature`.
8. [Optional]
   - Before aligning, it is advisable to visually inspect the your group average and the Glasser surface side by side and decide if the smoothness levels are similar. If not you need to go back to step 4 and adjust the smoothing levels.
   - To do that, load the Glasser surface for one hemisphere e.g. *HCP-Glasser2016_resampled_LH_HIRES_SPH.srf*.
   - Then Go to Meshes -> Add Mesh and select your group aligned averaged folded surface.
   - Press on `Mesh Transformation Pannel` from the Tools bar on the right and move one of them to see them side by side.
9. Align the Group Averaged Mesh with the Glasser Surface

- Load the Glasser surface for one hemisphere and go to Mehses -> Cortex-Based Alignment
- Go the the Target Sphere tab and load the Glasser curvature surface map and pres `Create PMP`
- Now go to the Align Group tab and select the `Align each entry to target sphere` option.
- Press `Add...` and choose the curvature smp that you created in step 7.

10. Map the Glasser POIs to the Average Surface
    - Reindex POIs of the Glasser atlas suface to the aligned average surface of your subjects using the surface-to-surface map.
    - You can use *glasser_to_average.m* as a starrting point and change the file names.
    - Make sure you use the inverted mapping in this step.
11. Map the Average POIs to each of the Subjects Surfaces
    - Reindex POIs of the average suface to the aligned subject surface using the surface-to-surface map of each subject.
    - You can use *average_to_subject.m* as a starrting point and change the file names.
    - Make sure you use the inverted mapping in this step.
12. Create VOIs out of the POIs
    - The POIs are in surface space. To convert them to volume space load the simplified mesh surface for each subject and load its corresponding POI file (ctrt+i).
    - Now go to Options -> POI Functions and in the `POIs -> VOIs` section select the vertical distance of the mapped patches. Its better to increase them to be safe. I used -3mm to 6mm. Press on `Create`.
    - After you create the VOIs you must explicitly save them.
13. Create ROIs Masks out of the VOIs
    - Now that you have the VOIs in surface space the last step is to create separate masks for each region of interest.
    - To do that you need the bounding box from a vtc to get the right coordinates of the functional data.
    - Iterate over the regions that are saved in the VOI and save them as masks with the cooredinates of the VTC.
    - To do that you can use the `CreateROIMasks.m` as a starting point.