Step by step guide to Deshify

Instructions are given below and in an instruction video on https://github.com/SofiaMockelind/qDESH on how to create the search volumes described in the paper and how to segment the final CSF-volumes. The search volumes were created using the free research software tool imlook4d (https://sites.google.com/site/imlook4d/), run within MATLAB R2023a, Natick, Massachusetts: The MathWorks Inc.; 2022.

Definitions

PC=the most anterior coronal slice of the posterior commissure

AC=the most posterior coronal slice to the anterior commissure

Create a list of 8 ROI's:

1 and 2 the right and left sylvian respectively: 3 high convexities: 4 Flood-fill block: 5 lateral ventricle: 6 posterior border: 7 and 8 the right and left opercular boarder (*Figure 1*)

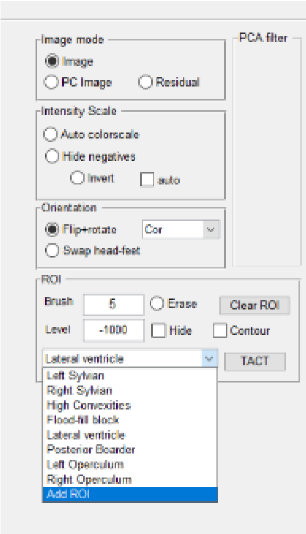

Figure 1. List of regions of interest (ROI)s as seen in Imlook4d

Border

Three boards are created to get higher reproducibility (*figure 2)*.

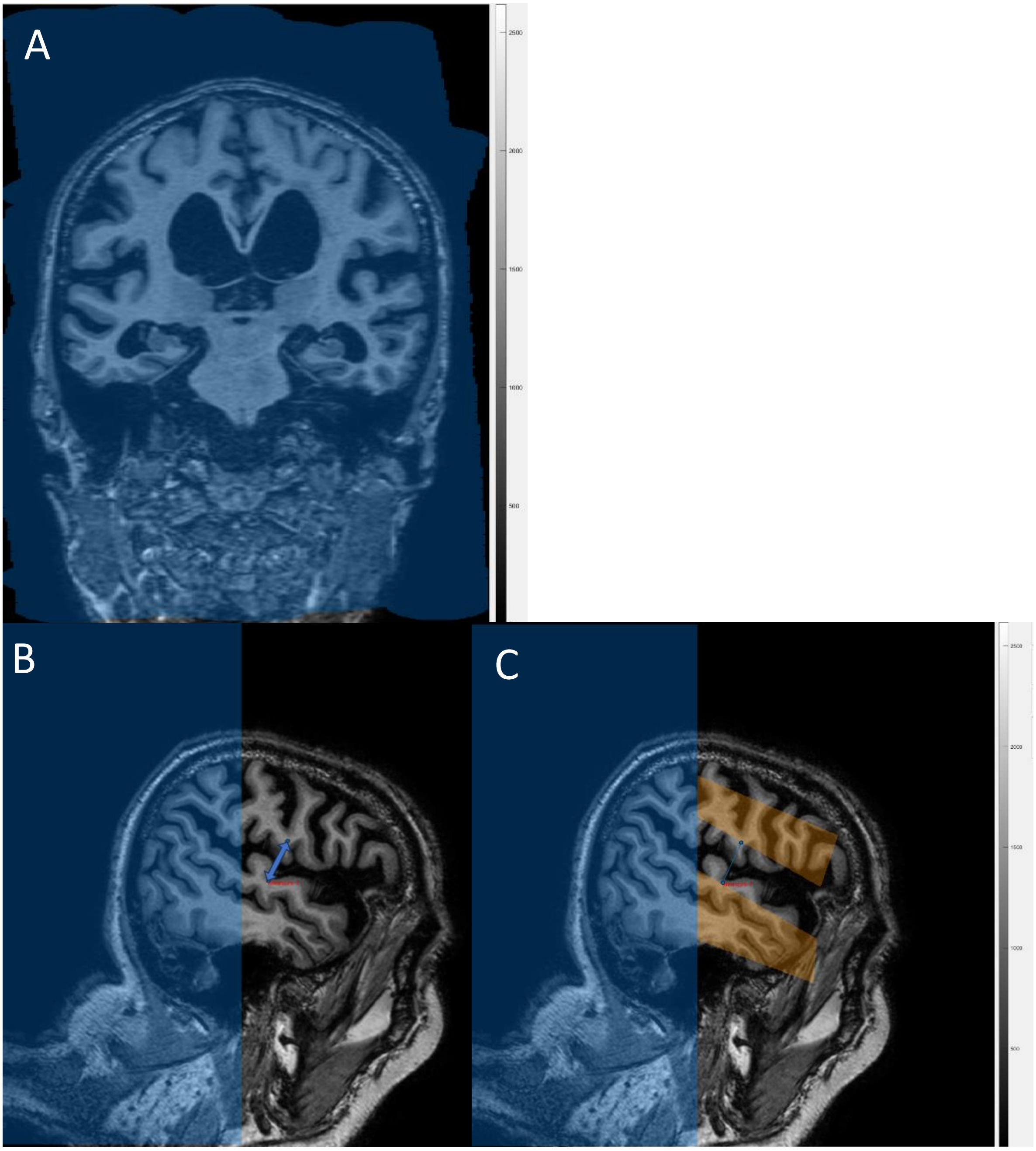

Figure 2. Posterior boarder (blue) and opercular margin (orange). A: coronal slice just posterior to the PC, showing the posterior boarder. B: Sagittal slice at the lateral boarder of the cerebellar convexity. Arrow marks distance of 2 cm. C: Same slice as in B but with added opercular margin, 2 cm apart as measured in B.

1. Figure 2A: Posterior boarder (blue). In coronal view. Cover the entire slice, posterior to the PC. Copy the ROI to cover the whole area posteriorly.

2. Figure 2B: Opercular margin (orange). In the sagittal plane, go to the lateral boarder of the cerebellar convexity. Measure 2 cm perpendicular to the Sylvian fissure (arrow), measured 1 cm each side from the midline.
3. Figure 2C: Using the measure, draw two boxes from the posterior boarder and anteriorly, parallel to the Sylvian fissure, 2 cm apart (perpendicular to the measured line). Copy this ROI to the most lateral slice in the image.
4. On the contralateral side, locate the lateral boarder of the cerebellar convexity. Note the slice number and copy the opercular margin in 2B to the located slice, ending at the most lateral slice in the image. Move the boxes, if needed, to adjust and recentre on the Sylvian fissure.
5. Lock all ROIs in this step.

Sylvian fissure search volume (green, figure 3)

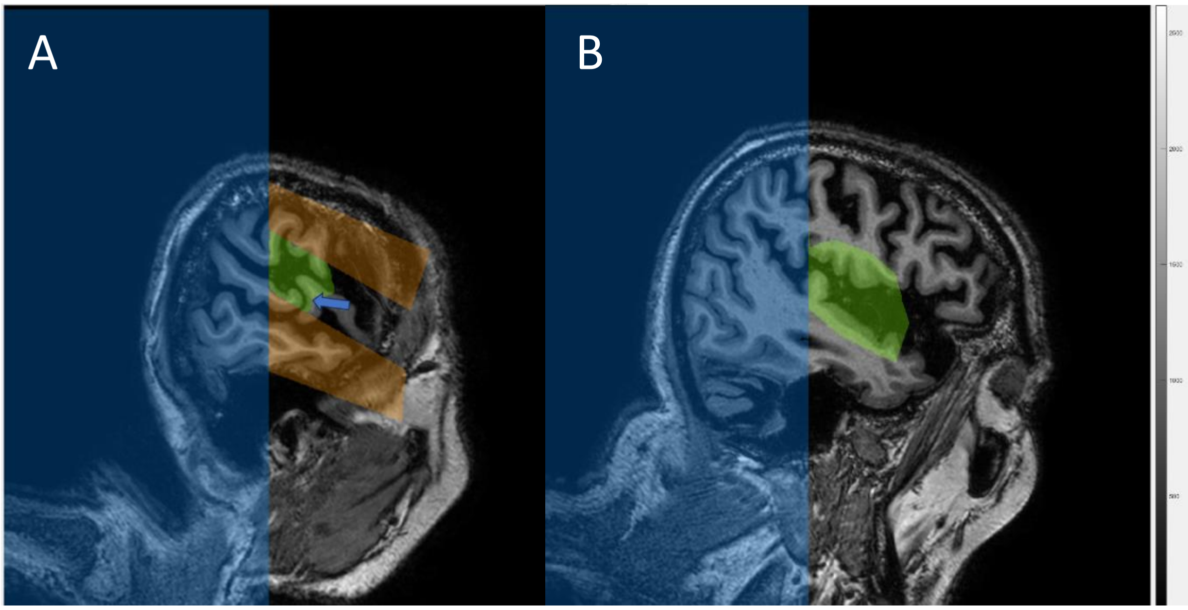

Figure 3: Sylvian fissure search volume (green), posterior boarder (blue) and opercular margin (orange). A: Sagittal slice highlighting a perisylvian sulci (arrow). B: Medial part of the Sylvian fissure not restricted by the opercular margin.

a. In the sagittal plane, cover everything from the dura to the lateral boarder of the cerebellar convexity (where the opercular margin ends), avoiding CSF not connecting directly to the part of the Sylvian fissure between the borders (*figure 3A*). If a perisylvian sulcus (arrow) connects to the Sylvian, it is included in the search volume in all slices if it connects to the Sylvian fissure. For the part of the Sylvian fissure medial to the opercular margin, all CSF connected to the Sylvian fissure is included (*figure 3B*).

b. For a faster process, only draw in a few slices and then interpolate the ROI between the slices. Repeat process for the contralateral side.

High Convexities search volume (blue, *figure 4*)

a. In the coronal plane, draw a ROI between the AC and PC following the dura, without covering the Sylvian fissures (you will erase them).

b. To not draw a ROI in every slice, draw a couple of slices and interpolate in between. The inferior boarder can be put at the roof of the ventricles and will be adjusted in postprocessing in a later step.

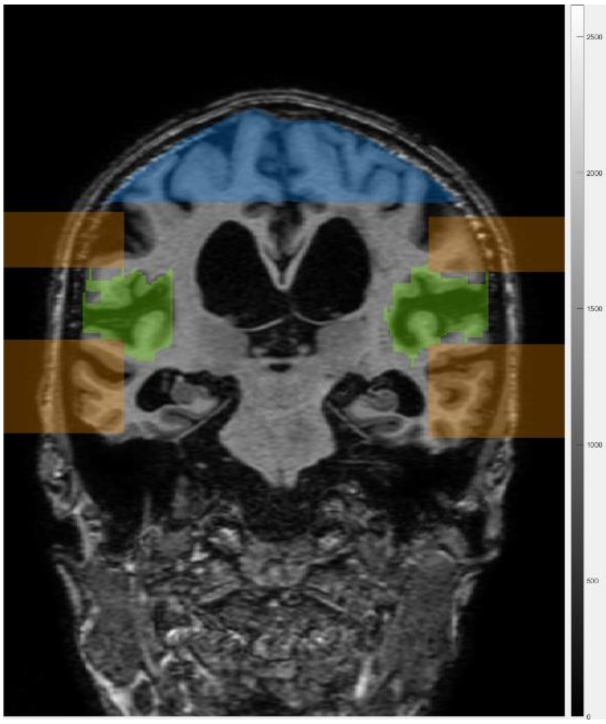

Figure 4. High convexities search volume (blue), Sylvian fissures search volume (green) and opercular margins (orange).

Flood-fill block (orange, figure 5)

(Optional, do if exact lateral ventricular volume is of interest)

To prevent the flood-filling from causing "leakage" of the lateral ventricle ROI in step 6, draw a crude ROI at the floor of the lateral ventricles, stretching down medially to the temporal horns. When completed, lock the ROI.

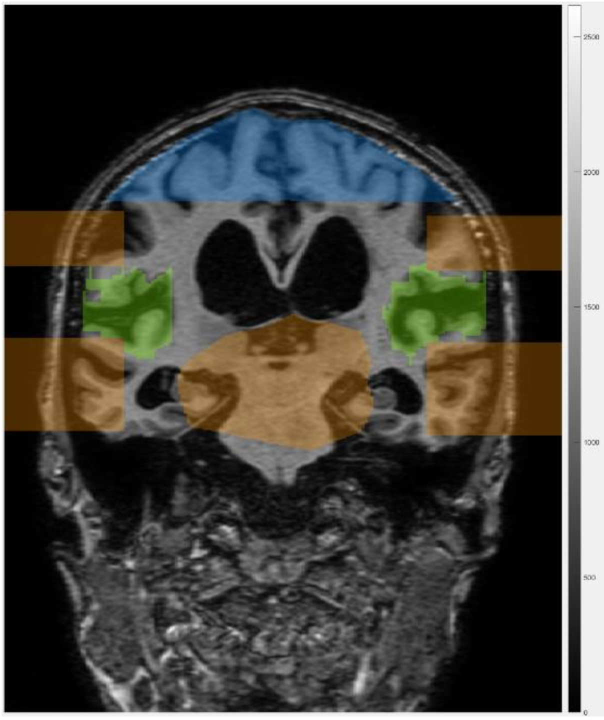

Figure 5. Flood fill block (centre orange), opercular margins (lateral orange), Sylvian fissures search volume (green) and high convexities search volume (blue).

Lateral ventricle (red, figure 6)

Start by unlocking the posterior boarder.

Place a seed in the lateral ventricle. Export the data to identify the highest pixel-value. Use a value slightly above the highest pixel value in the seed for the flood-fill function. If the ventricles are not filled enough, use a higher value, and redo the flood-fill. If there is leakage despite using a value just over the maximal one, selecting a different pixel and redoing the process should fix it.

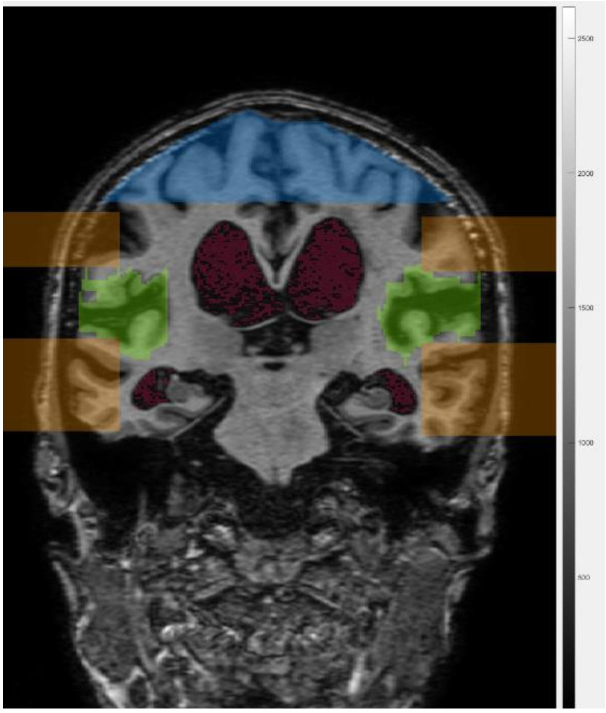

Figure 6. Lateral ventricle (red), Sylvian fissures search volume (green), high convexities search volume (blue), opercular margins (orange).

Final steps

a. <u>SAVE your progress.</u>

b. Unlock and remove all borders.

c. Follow the steps in the Deshify application for postprocessing. The scripts used are described below. As a last step, you are given the calculated qDESH (figure 7)

Figure 7. Final cerebrospinal fluid (CSF) volumes of the Sylvian fissures (green), high convexities (blue) and lateral ventricle (red) after postprocessing with Deshify.

In house scripts

Four separate scripts are used to generate the final cerebrospinal fluid (CSF)-volumes. The scripts are found on https://github.com/SofiaMockelind/qDESH.

1. To analyse the same area among subjects, the high convexies and Sylvian fissures search volumes are erased anteriorly to save the chosen number of slices anterior to the posterior commissure. In the paper, we kept the number of slices closest corresponding to 20 mm (*figure 8*).

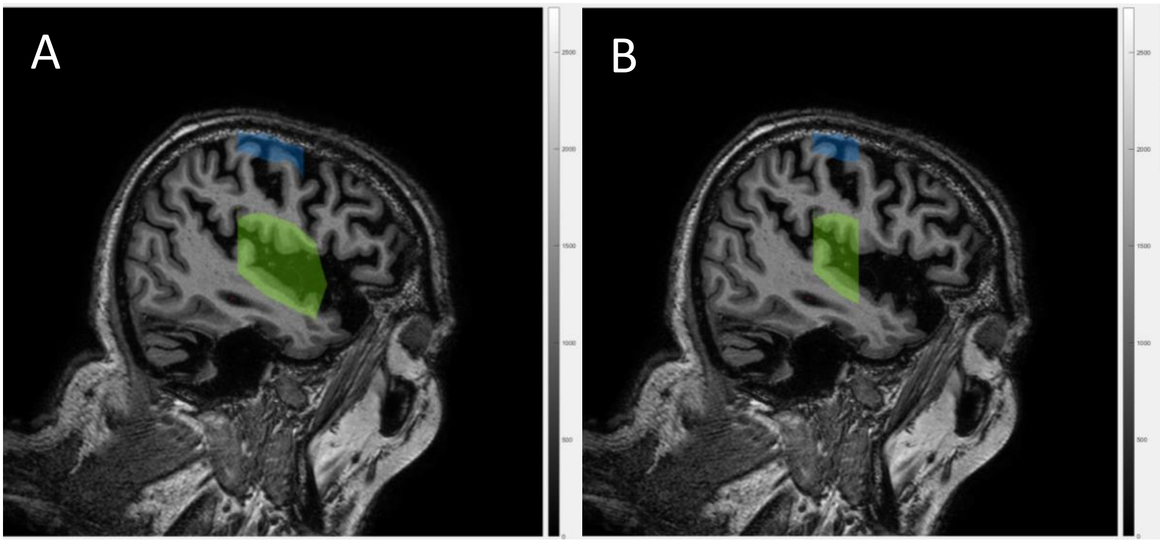

Figure 8. A: before slice fixation. B: after slice fixation. Sylvian fissure in green and high convexities in blue.

2. To get an equal search volume in between subjects, the high convexities search volume was further shrunk from below to a volume of 30 cm^3 (*Figure 9*). We chose this volume as it was found to be the largest volume containing the least number of focally enlarged sulci. Focally enlarged sulci are another known feature of NPH [11]

and inclusion of these could result in a falsely high CSF volume in an otherwise tight high convexities space.

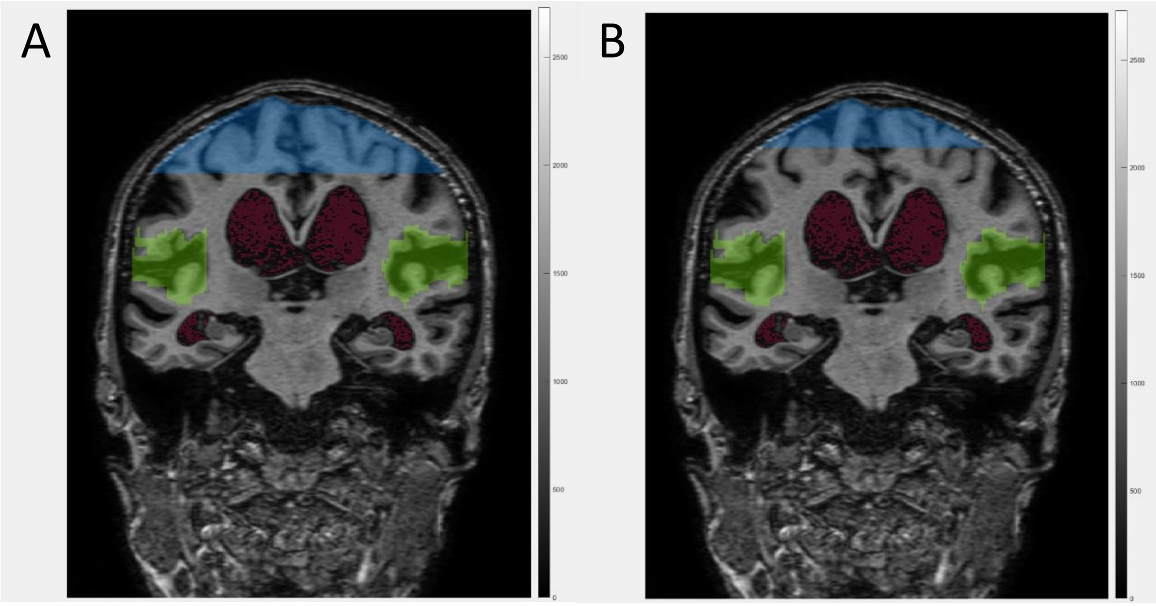

Figure 9. Before (A) and after (B) shrinking of the high convexities search volume (blue). Sylvian fissures search volume (green) and the lateral ventricle (red).

3. To not influence the pixel intensity value in the lateral ventricle by choosing a flood-fill value, the lateral ventricle search volume was inflated to cover the CSF and some neighbouring brain tissue (*figure 10*).

Figure 10. Inflated lateral ventricle (red), Sylvian fissures search volume (green) and High convexities search volume (blue).

4. Search volumes were segmented on a global threshold value created from the Sylvian fissures, high convexities, and lateral ventricle search volume. The threshold value was found by a script, defined as the signal intensity midway between the identified CSF and grey matter peaks *(figure 11)*. The lateral ventricle was needed for this process to work in all cases as some subjects otherwise had to little CSF in the combined search volume for the script to identify the CSF.

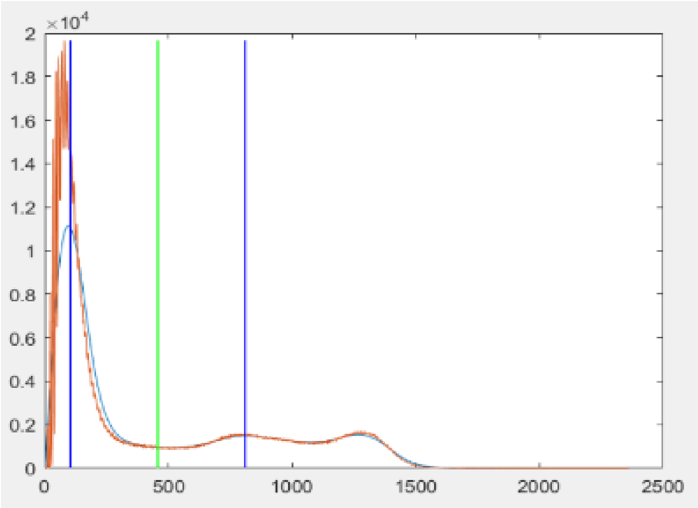

Figure 11. Histogram illustrating the cerebrospinal fluid (CSF) and grey mater (blue lines) peaks as identified by the script. The green line illustrates the global threshold defined as the signal intensity midway between the identified CSF and grey matter peaks.

5. As a last step, qDESH is calculated. The calculation is corrected for differences in high convexities search volume due to differences in pixel size between the images (*figure 7*).