

ECOG ELECTRODES VISUALIZATION TUTORIAL

To visualize electrodes on a brain cortex we need MRI preimplantation and CT post-implantation scans series. For cortical surface extraction we have to use T1 MRI scan that contain no less than 160 slices. First of all we have to extract T1 scan series from data obtained from clinicians. This can be done with medical images viewer, for example, OsiriX for macOS platform or RadiAnt for Windows platform.

Cortical surface extraction can be carried out using FreeSurfer software. After FreeSurfer installation according recommendations from official website run the following command in a terminal:

```
recon-all -i folderContainingMRI_T1_scan_series/IM-0001-0001.dcm -s subject_name -all
```

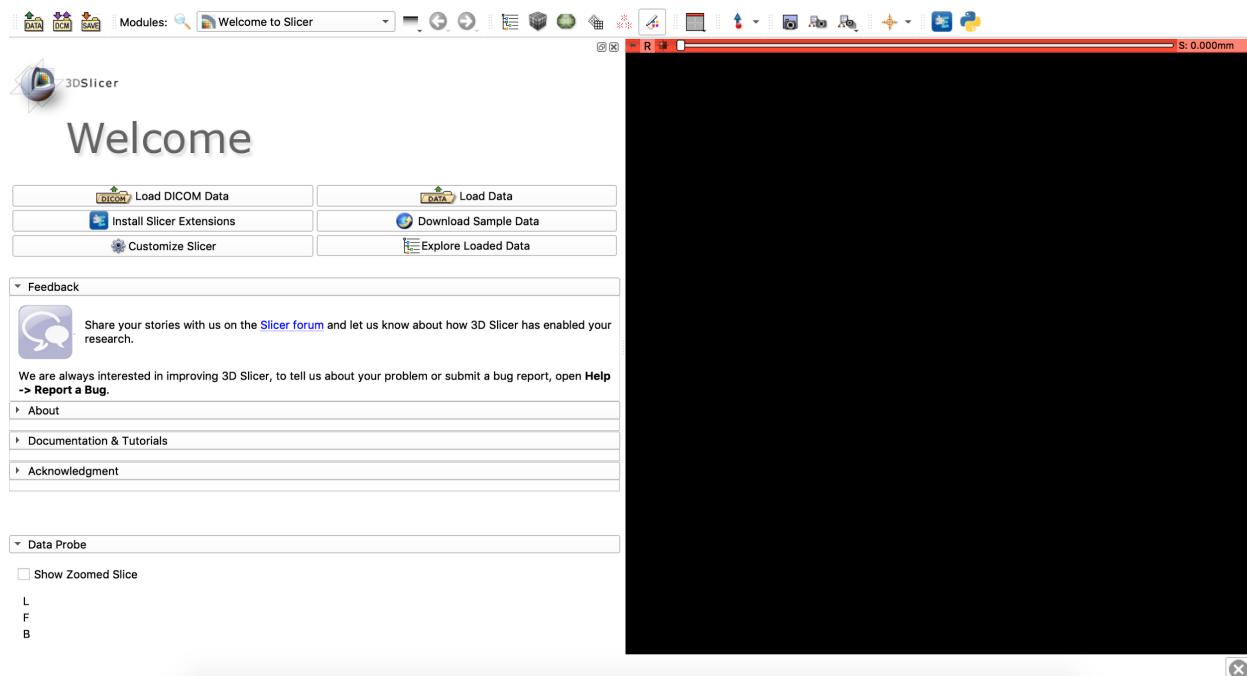
This command will run the full FreeSurfer processing pipeline.

folderContainingMRI_T1_scan_series/IM-0001-0001.dcm has to be the path to one *.dcm file in the directory, FreeSurfer will figure out the rest.

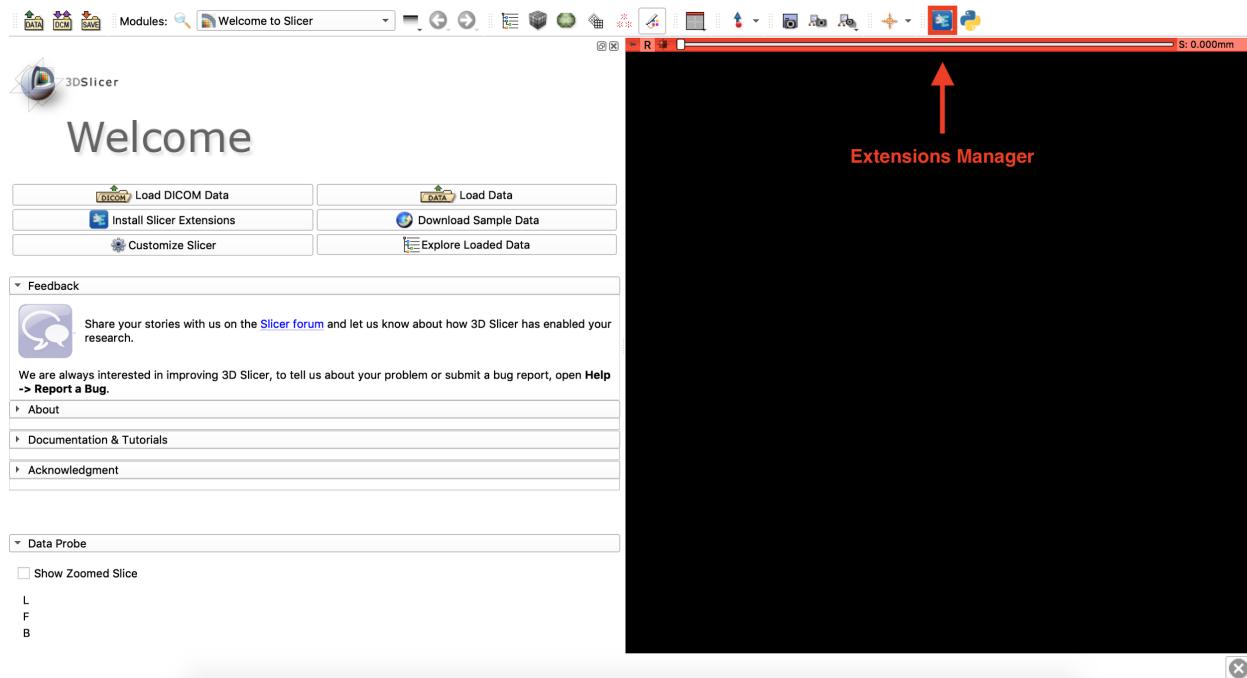
subject_name has to be the name of the output directory that will be created by FreeSurfer.

Resulting surfaces can be found under **freesurfer/subjects/subject_name/surf**: lh.pial and rh.pial are left and right halves of cortical surface respectively.

For electrodes visualisation on brain cortex we have to perform MRI and CT volumes registration. For this purpose we can use 3D Slicer software.



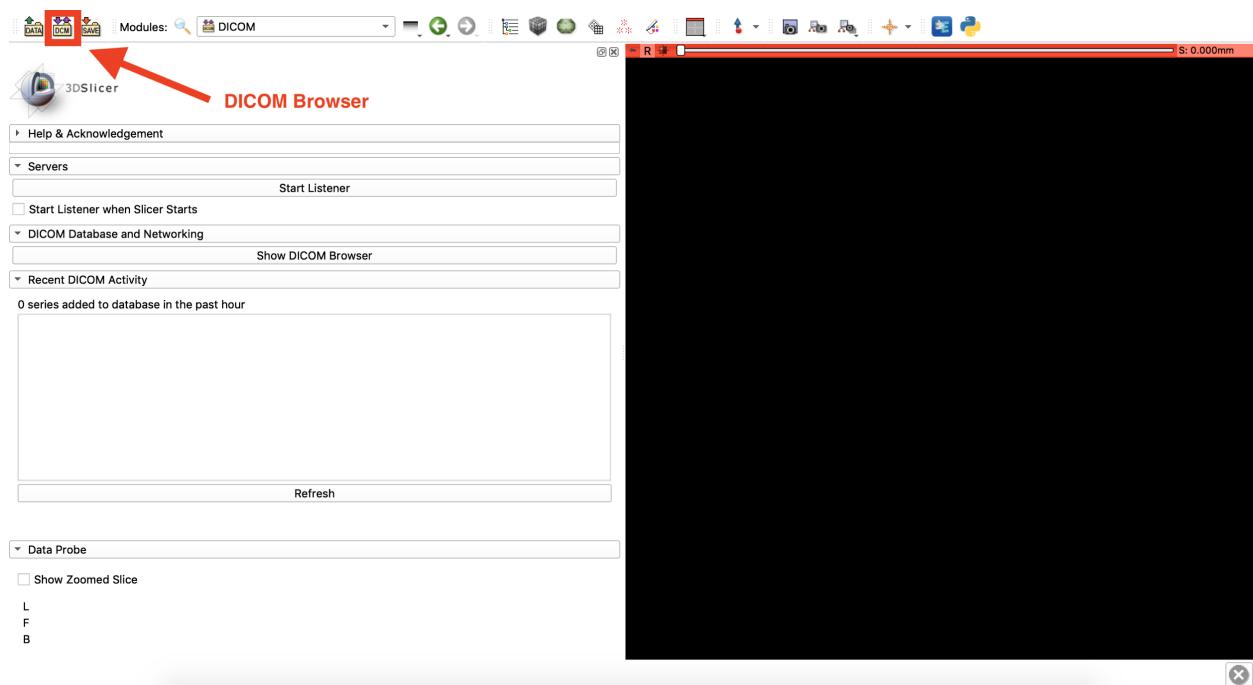
To obtain fine result ElastiX plugin can be used. Use Extensions Manager to install ElastiX plugin in 3D Slicer.



You can find ElastiX plugin using search field. After installation 3D Slicer have to be restart to activate plugin.

A screenshot of the "Slicer Extensions > Registration" page. At the top, there are buttons for "Manage Extensions (11)", "Install Extensions", and "Restore Extensions". A search bar contains the text "elastix". The main content shows a listing for "SlicerElastix" by Andras Lasso (PerkLab, Queen's University). It includes a thumbnail image of the ElastiX logo, an "INSTALL" button (which is highlighted with a red box), and a description stating "This extension makes available Elastix medical image registration toolbox (<http://elastix.isi.uu.nl/>) available in Slicer.". Below the description are sections for "Links" (with links to the home page and source code) and "Screenshots" (showing two small images of medical scans). There is also a "User Comments" section with a note that says "Login or register to add a comment." and "0 comments on this item". At the bottom right of the page are "Close" and "Restart" buttons.

DICOM data can be loaded using DICOM browser



Firstly CT and MRI scans have to be imported to DICOM Browser. Then they can be loaded to 3D Slicer work space.

The screenshot shows the DICOM Browser interface with the "Import" button highlighted by a red box. The interface includes search fields for "Patients:" and "Studies:" and a "Series:" search field. Below these are three tables:

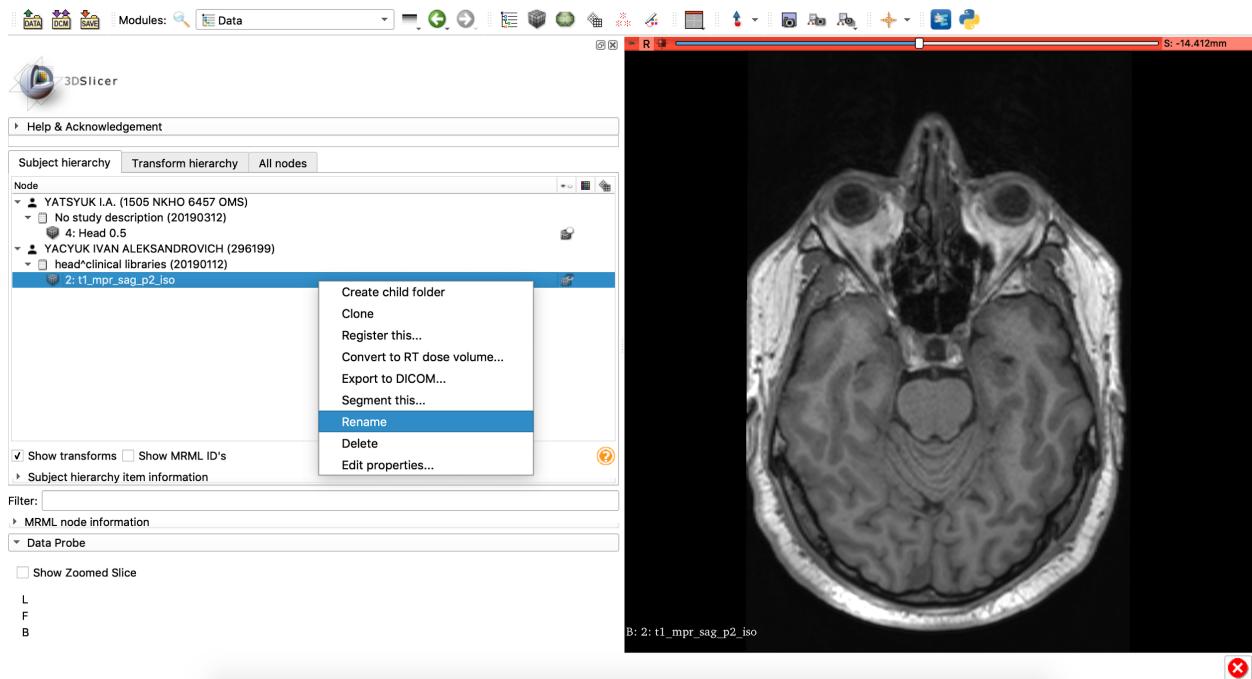
PatientName	PatientID	PatientsBirthDate	PatientsBirthTime	PatientsSex	PatientsAge	PatientsComments
YACYUK IVAN ALEKSANDROVICH	296199	1986-11-28		M		
YATSYUK I.A.	1505 NK...457 OMS			M		

StudyID	StudyDate	StudyTime	AccessionNumber	ModalitiesInStudy	InstitutionName	ReferringPhysician	PerformingPhysiciansName	StudyDescription
1	2019-01-12	113034.026000	PL869346		Medical Club Consilium MRI 3T		Grigor'eva E.V.	head\clinical libraries
1505	2019-03-12	133434.8000	1505		MGMSU im. Evdokimova			

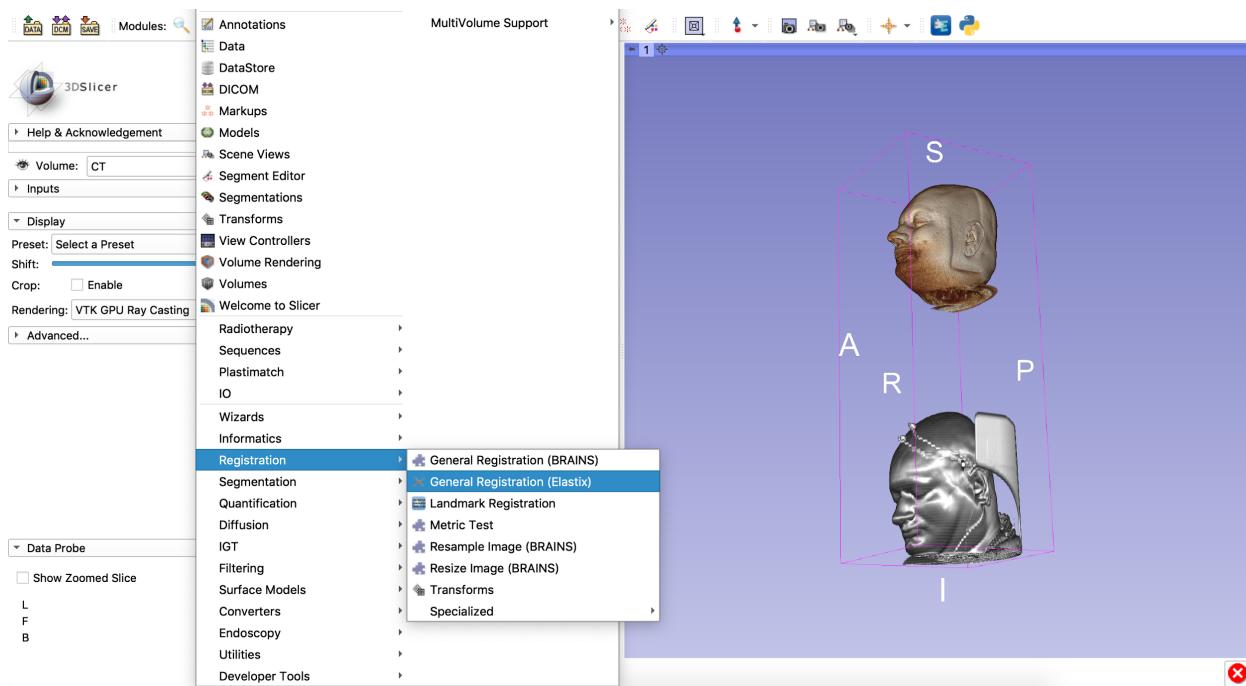
SeriesNumber	SeriesDate	SeriesTime	SeriesDescription	Modality	BodyPartExamined	AcquisitionNumber	ContrastAgent	ScanningSequence	EchoNumber	TemporalP
2	2019-01-12	114241.624000	t1_mpr_sag_p2_iso	MR	HEAD	1		GR	1	0
4	2019-03-12	133731.828	Head 0.5	CT	HEAD	3			0	0

At the bottom, there are buttons for "Load" and "Metadata", and checkboxes for "Advanced", "Horizontal", and "Browser Persistent".

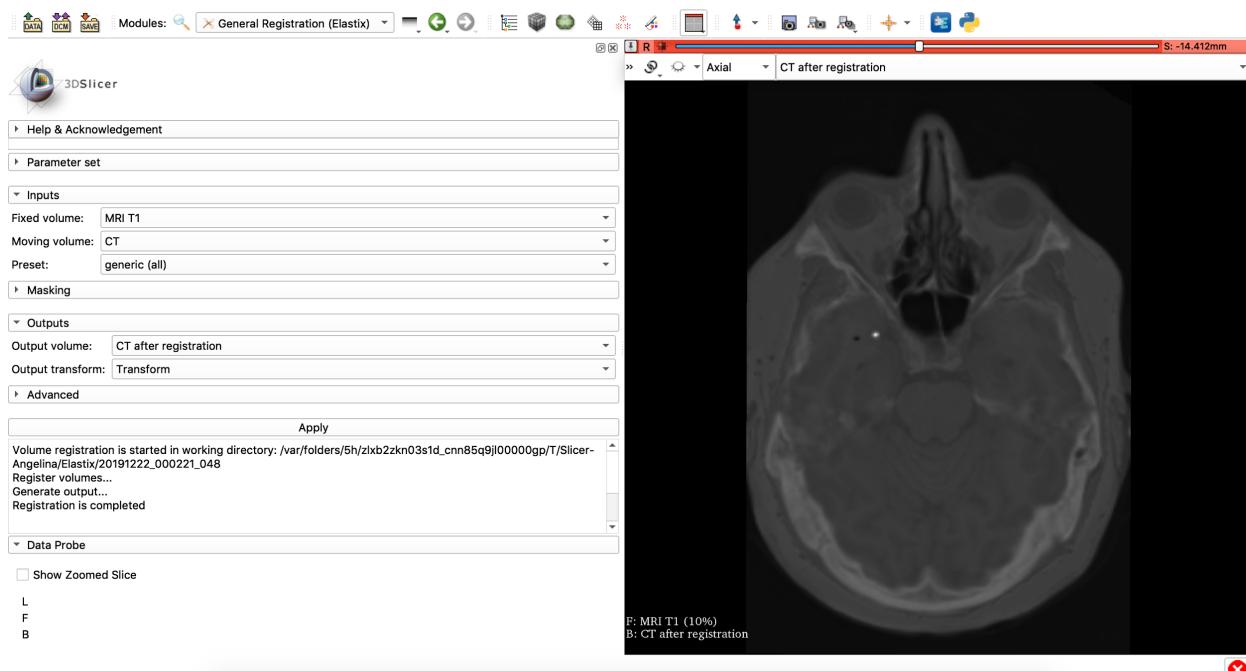
The data can be renamed to facilitate further manipulations.



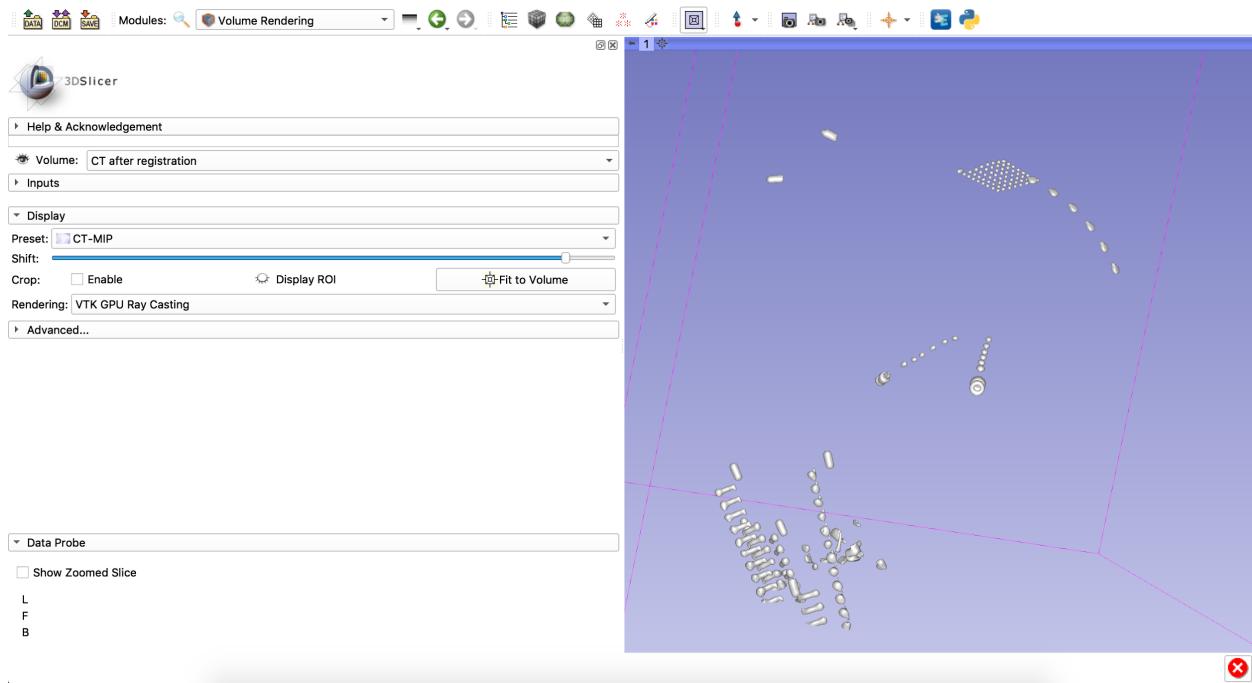
In Volume Rendering workspace we can see that CT and MRI volumes are not aligned. So we have to perform co-registration using ElastiX plugin.



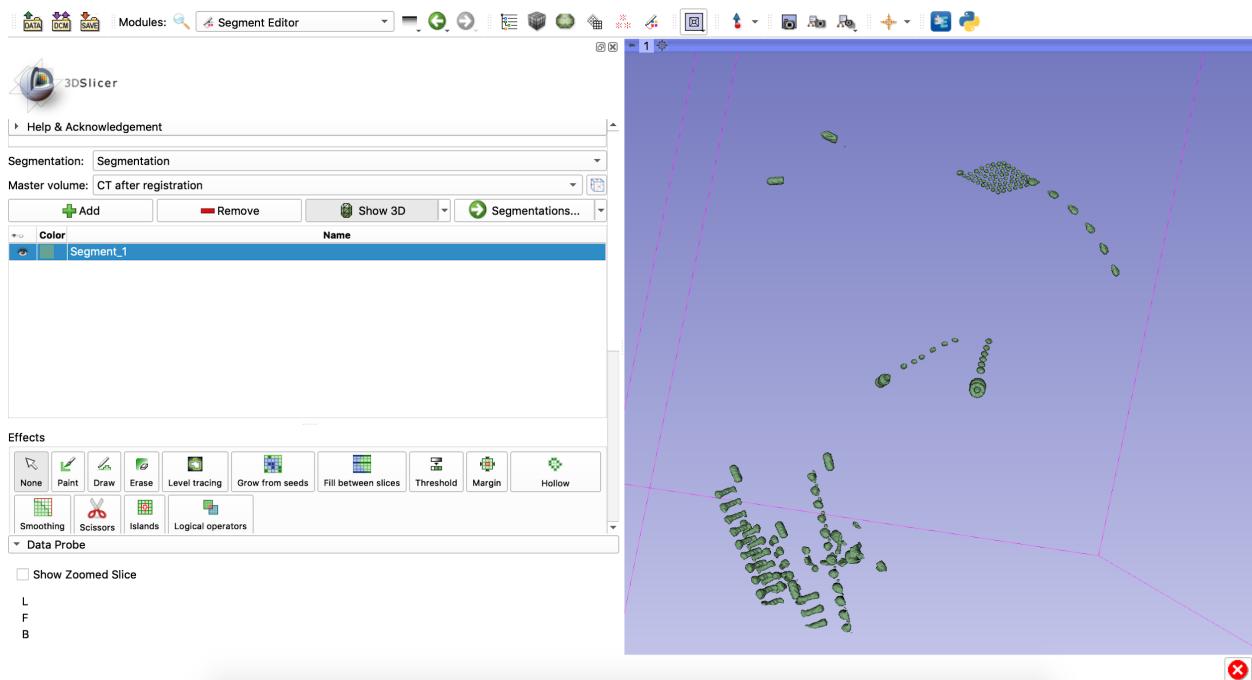
To run ElastiX registration Inputs and Outputs have to be specified.



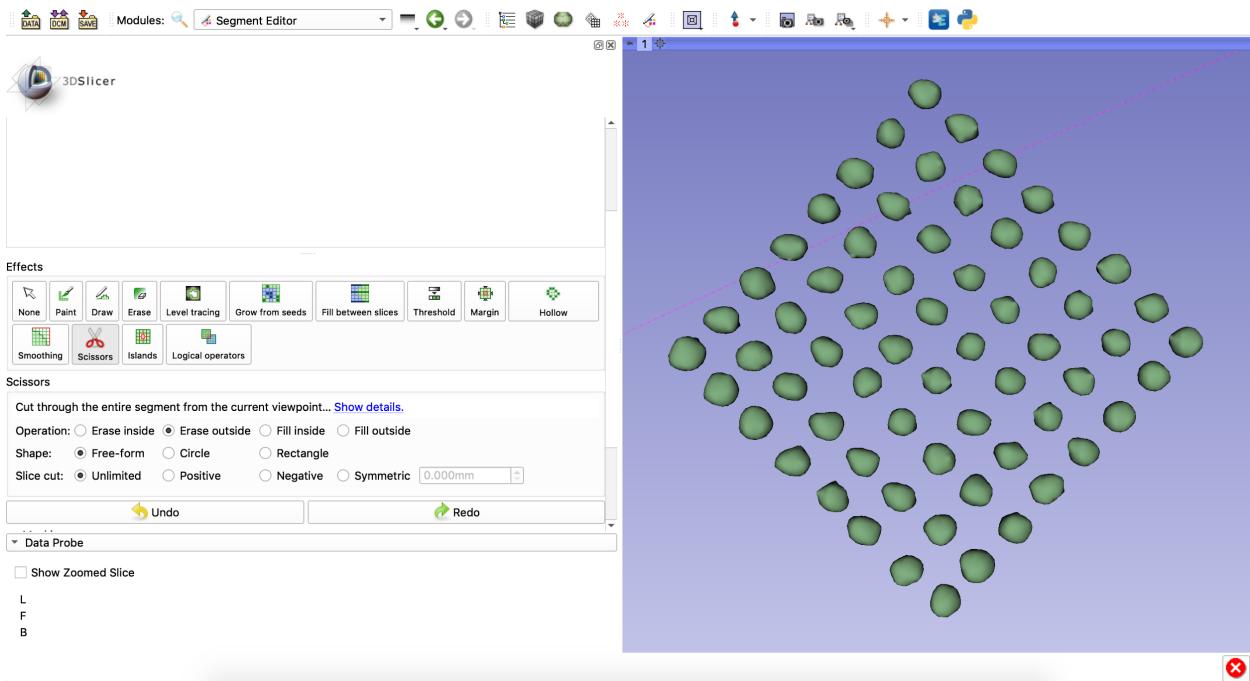
After co-registration we can extract electrodes as segmentation.



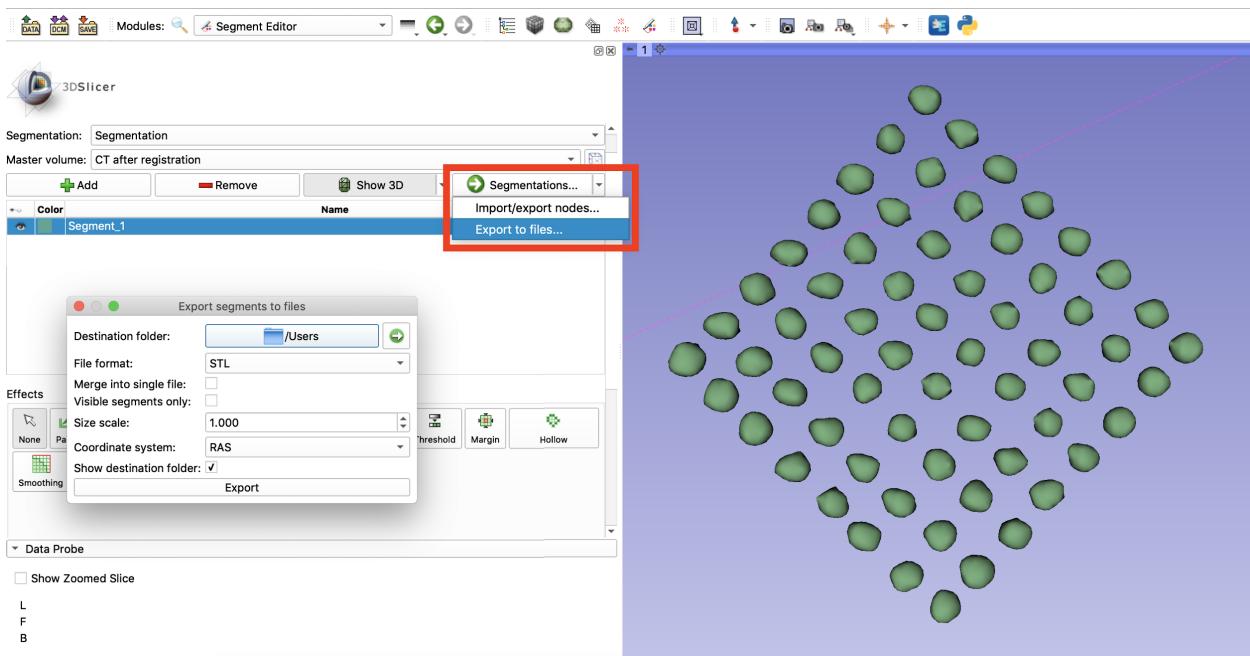
All electrodes can be extracted using threshold module.



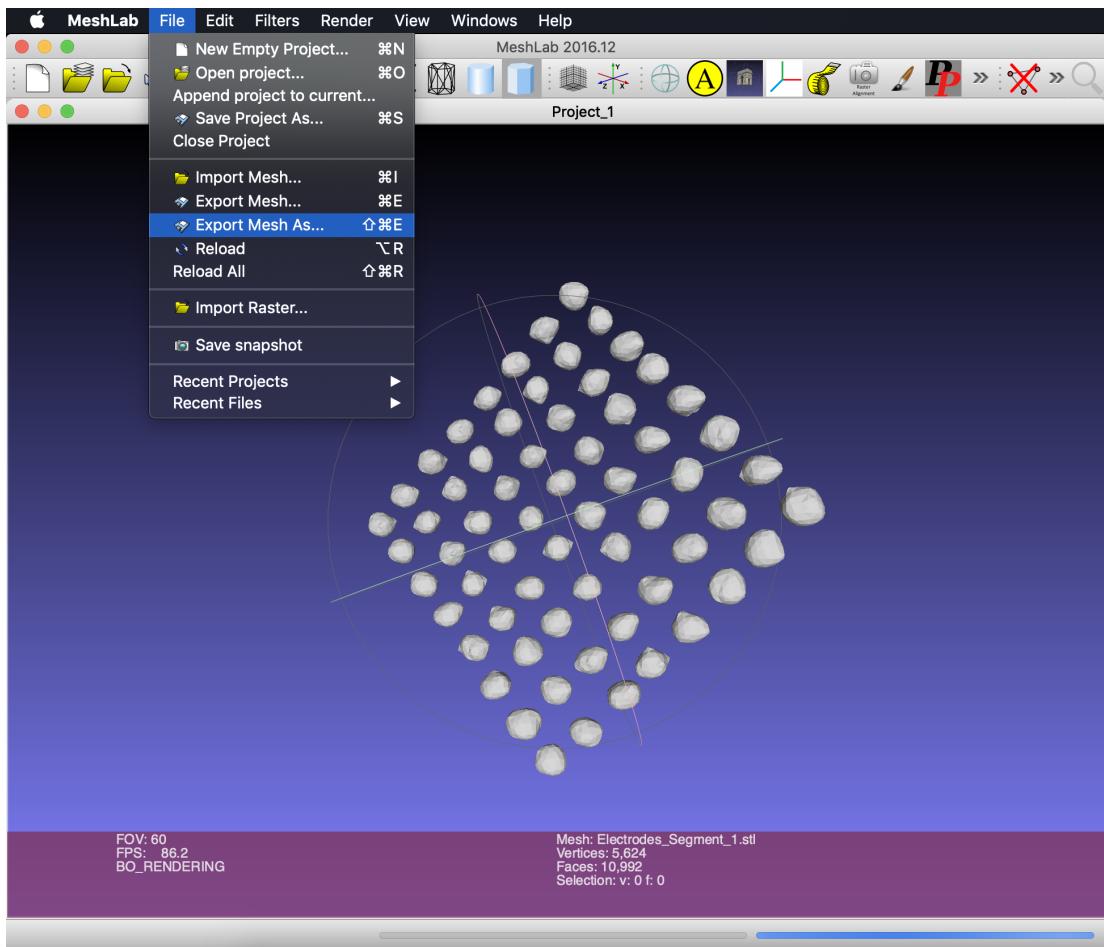
Then appropriate electrodes can be extracted using scissors



Export segmentation

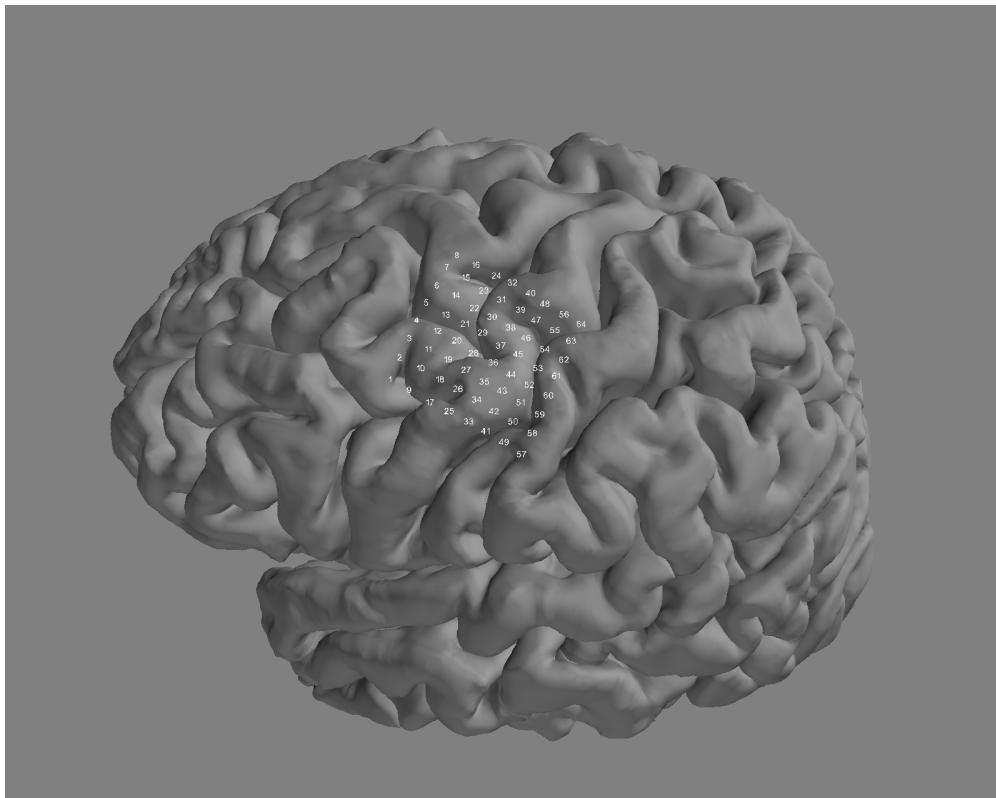


To be processed in Python .stl file have to be converted to .xyz format. For this purpose MeshLab software can be used. Export mesh as .xyz without normals.

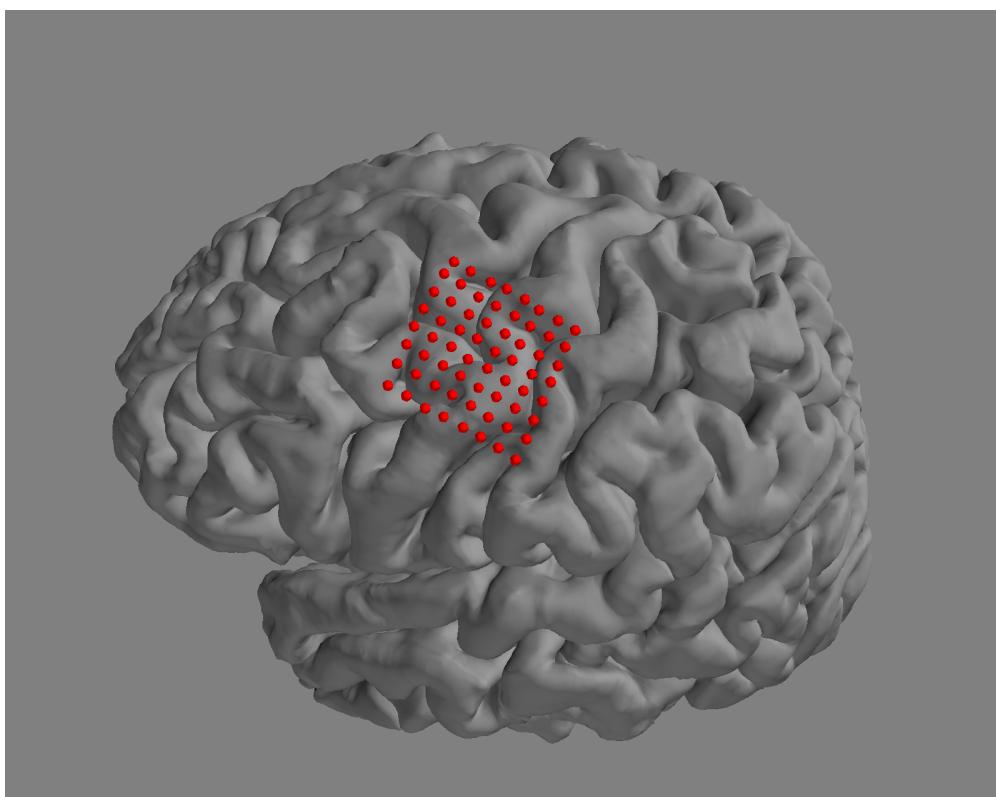


After all preparations data can be loaded to open source cross platform software for visualisation of ECoG data on cortex surface developed by us.
In the first block we carry out all processing for further ECoG data visualisation.

We can plot electrodes as numbers to check their order

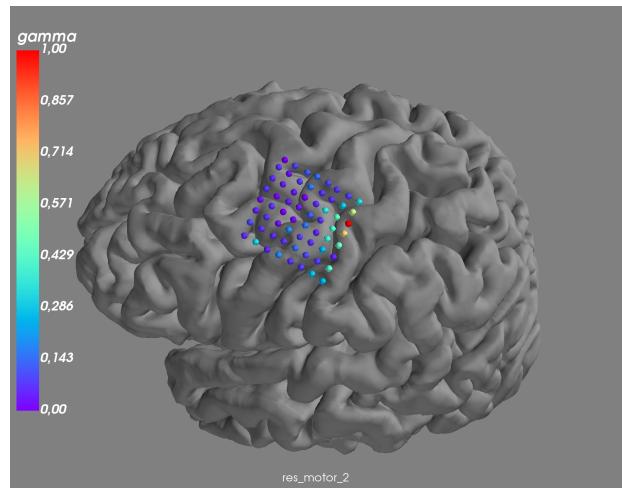
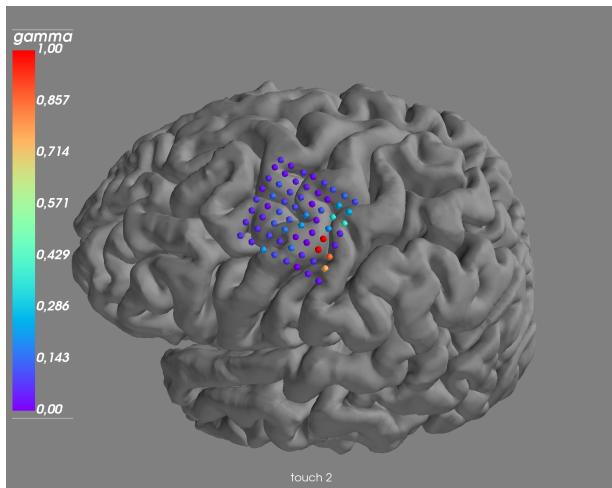
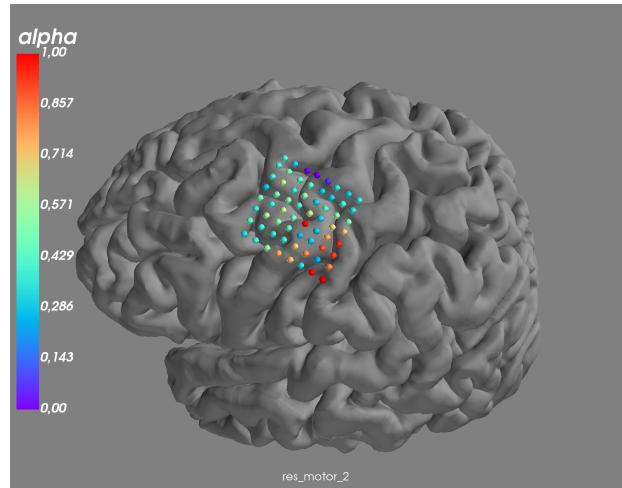
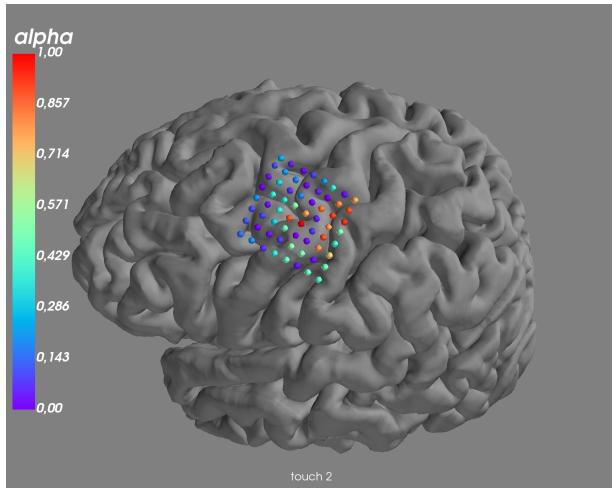


We can plot electrodes as spheres to check their locations.

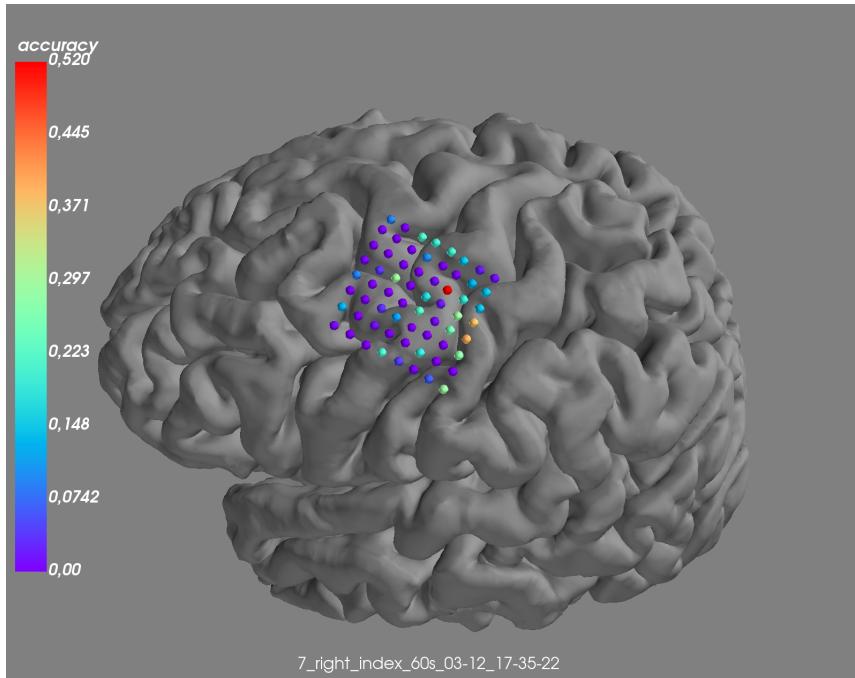


In the second block we can visualise ECoG data on electrodes and save results if needed.

Here are some examples of ECoG data visualisation. (4 pictures panel)
Alpha and gamma motor and sensor activity.



Accuracy of fingers movement decoding.



As electrodes are connected in grid we can model mesh deformation using thin plate spline.

