Electrode placement (*eplace*)

eplace is a Matlab GUI program for intracranial electroencephalography electrode placement.

eplace uses *Freesurfer*'s Matlab toolbox to read brain images.

Testing info: Matlab R22020b, macOS Mojave 12.2.

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- ## Load an image

  File → **Open** Choose a postoperative CT image.

- ## Load labels (Optional)

  Load → **Label** Load labels of the electrodes which must be a text file with one label per row.

- ## Place an electrode

  Move the cursor on/close to an electrode, press **Add** button or "**a**" on keyboard.
  If an electrode was identified successfully, it will be added to **Electrode Name** as *label***.*
  If the real electrode labels have been imported using **Load** → **Label**, you can choose a label in **Read Label** and press the "**<**" button or "**,**" on keyboard to rename the label in **Electrode Name**.
  We can also enter the label name in the box next to the **Rename** button, then press the button.

- ## Preview an electrode

  To preview a label in order to adjust the parameters, use **Preview** instead of **Add**.

- ## Remove label

  Move the cursor on an electrode, or click a label in **Electrode Name**, then press **Remove** or "r" on keyboard.

  To view all electrodes in 3d mode, check **Show all coordinates.** A new figure will pop out with each dot representing one electrode. The current cursor location will be indicated as red.

- ## Options for electrode placing

Note. Default options work well in most cases.

Local Peak. Search for the local peak within a sub-region centered at the cursor location.
Center Estimation. Estimate a center from a sphere sub-region centered at Local Peak.
Separate Overlaps. When two or more electrodes are overlapped, it MAY help to separate them by adjusting those parameters.
Final Sigma. Controls the final size of the electrode.
Use Exact. Use the cursor location as the electrode location.
Use Peak. Use the peak as the electrode location.
Cubic. Draw a 3d box and threshold it to place the electrode. See below for how to draw a box.

To draw a 3d box, hold down right mouse button. Right click on the image to eliminate a box. We just need to draw the box on two of the three images.

Change the type of coordinates in the **Settings** tab.

- ## Save results

File → Save

The result can be re-loaded for later editing using **Load → Electrodes**.

The result *elec* is a data structure with following fields.

```
% electrode labels, N x 1 cell string
elec.label
% electrode coordinates
elec.elecpos
elec.elecpos.coord % N x 3 mm coordinates
elec.elecpos.coord_type % default unweighted center
elec.elecpos.img2mm % transformation matrix from voxel to mm
```

```
elec.elecpos.dims % matrix size of the 3d brain volume
elec.elecpos.unit % unit of the cooridnate
elec.elecpos.sourcefile % source file for electrode localization
```

Things to do next

1. Transfer coordinates from CT space to individual anatomical or standard MNI space. This includes the normalization of CT image to T1 image and T1 image to standard brain using FSL's *flirt*. The resulting transformation matrix can be applied to the coordinates that are in CT space.

   Plot the electrodes in new spaces to make sure the transformations are accurate.

2. Brain tissues shift correction, e.g., project grid electrodes to surface.

Apply transformation matrix (*enorm*)

enorm is a Matlab GUI program for intracranial electroencephalography electrode placement. ***Freesurfer*'s Matlab toolbox is required**.

Testing info: Matlab R2020b, macOS Mojave 12.2.

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- ## Load *eplace* result

  Menu **File** → **Load**. Matlab data file generated by *eplace*.

- ## Coordinates transformation

  The "**Transformation Setup**" tab.

  Set the CT, T1, Standard images and transformation matrix that were generated using **FSL's *flirt*** (see ***RegCT2STD.sh***).

  Use "Auto Fill" to setup the transformation files automatically.

- ## Visualize electrodes

  Press "**Apply**" under the "**Transformation Setup**" tab.

- ## Electrode List

  The "**Explore**" tab.

  Click on the labels in '**Channels**" to navigate through all electrodes.

- ## Brain tissue shift correction (Electrode Projection)

  Setup the grid size (1 x 2 vector).

  Choose which method to use in "**Method**".

  The results will be saved in the '***proj***' field of the result data structure.

- ## Atlas query

  Press "**Query**".

  The results will be saved in the '***atlas***' field of the result data structure.

  Freesurfer label and FSL's HarvardOxford atlas label will be determined for each electrode.

- ## Save results

  The following fields will be added to the result data structure generated by ***eplace***.

  '*reg'*, electrode coordinates in T1, MNI, surface spaces.

  '*proj'*, projected coordinates.

  '*atlas'*, atlas query results.

  '*srcdata'*, source brain volumes, surface etc.

  In the '*reg*' and '*proj*' fields:

  '*coord2t1*', mm coordinates in individual anatomical space.

  '*coord2std*', mm coordinates in standard space.

  '*coord2surf*', mm coordinates in individual surface space.

  proj.status, 1). 1-the coordinates have been projected,

  2). 0-the coordinates have not been projected.

Visualize results (*eviewer*)

eviewer is a Matlab GUI program for intracranial electroencephalography electrode placement. ***Freesurfer*'s Matlab toolbox is required**.

Testing info: Matlab R2020b, macOS Mojave 12.2.

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eviewer is quite similar to ***enorm***. You can do everything using ***enorm*** and save the results and gave the resulting file to another people, then they are use only ***enorm*** and the **.mat* to visualize the results interactively without having all the raw data on their computers.