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 R2018a, macOS Mojave 10.14.5.

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- ## Open 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 appear in **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.

- ## 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.

```
% cell array, index of all voxels for each electrode
elec.rois
% electrode labels, N x 1 cell string
elec.label
% hand-drawn ROIs, to implement
elec.mask
% voxel -> ras transformation matrix, returned by MRIread
elec.coord.trans
% matrix dimension of raw image
elec.coord.dims
% full-path-to-raw-image
elec.coord.src_img
% real world coordinates
elec.coord.peak = [];
elec.coord.unweighted_center = [];
elec.coord.weighted_center = [];
elec.coord.img_peak = [];
elec.coord.img_unweighted_center = [];
elec.coord.img_weighted_center = [];

% use unweighted center in mm as default
elec.elecpos.coord = elec.coord.unweighted_center;
```

```
elec.elecpos.coord_type = 'unweighted_center';
```

The result can be viewed later using *eplace*.

Three more fields (namely *reg*, *proj, and atlas*) can be added to this data structure outside *eplace*.

What's 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 tissue shift correction. E.g. Project grid electrodes to surface.