EEG Signal Processing CHW5
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December 2023

Contents

1 A

Note that the R parameter of the model has three values and we should choose the largest one because it corresponds to the outer radius of the brain. Also, unit selection doesn't matter at all; Just be careful about the similarity of R and resolution. Figure 1 obtained using ForwardModel_3shell function.
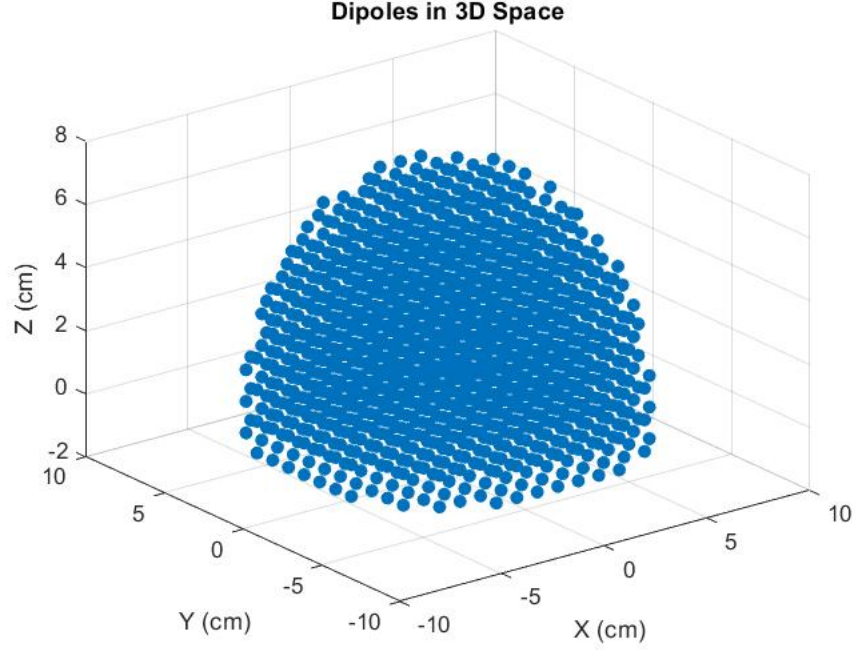

Figure 1: All Possible Dipoles in 3D space

2 B

ElecPosXYZ file has been loaded and the electrode positions and names are plotted alongside the dipole positions in the figure 2.

3 C

the result is shown in the figure 3. First of all, we find surface dipoles using defining a threshold of 0.85 of brain radius. Then find its direction using its location. Finally, we plot the diploe location and direction.

4 D

We load and select the first row of the Interictal matrix as a spiky activity. The size of the G matrix is $N \times 3P$ which N is electrode number and P is dipole number. So Q matrix should be $3P \times timeSamples$. See figure 4.
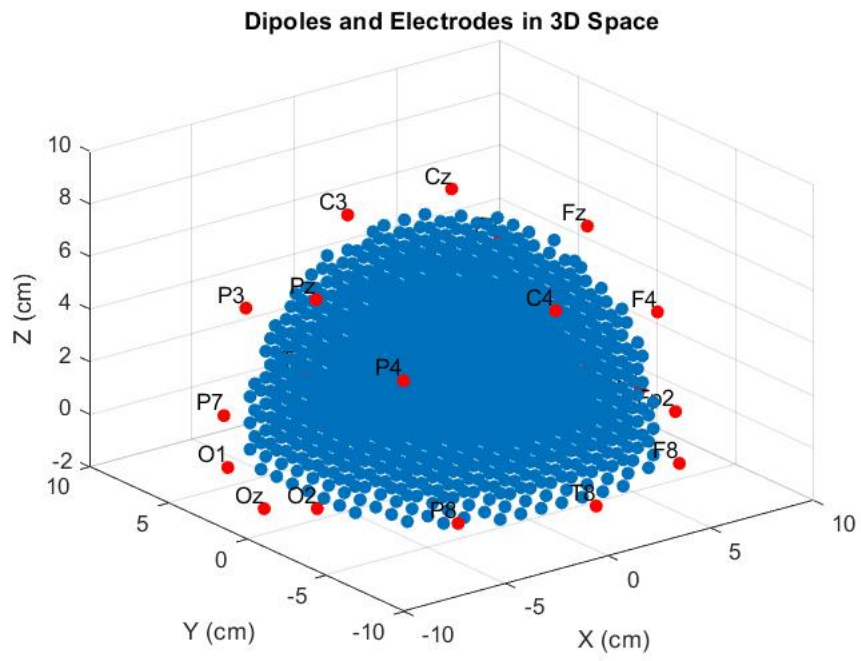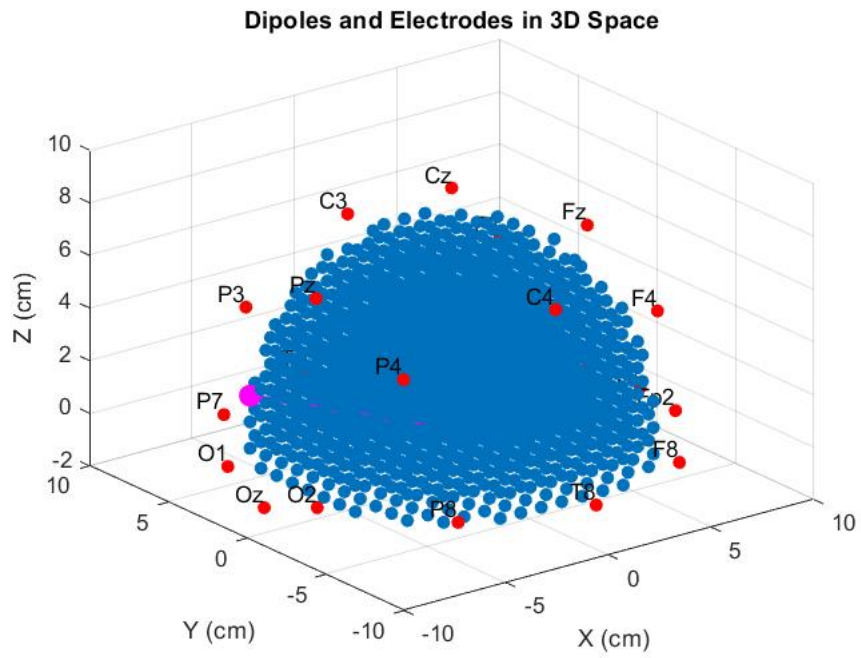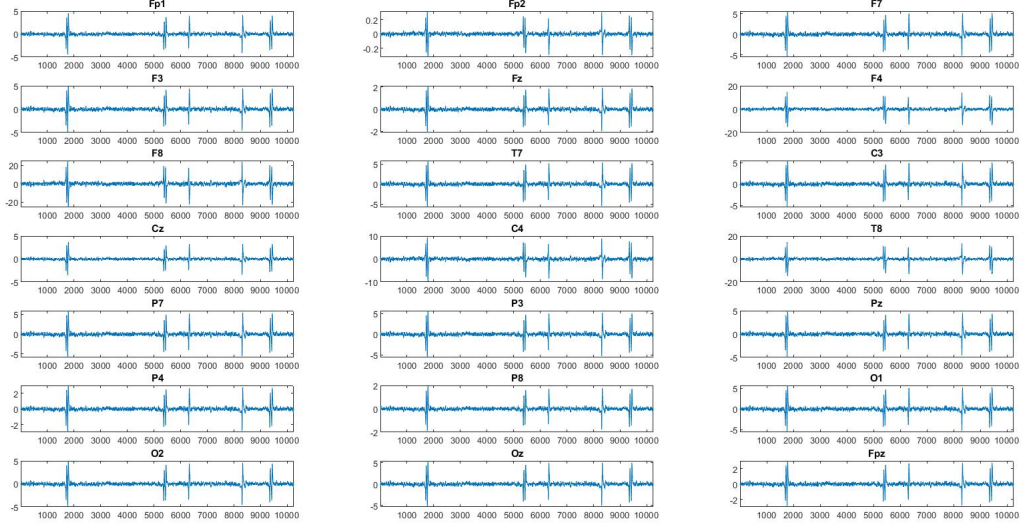
Figure 2: Also Electrodes!

Figure 3: New Dipole

4

Figure 4: electrodes Potential

.

5   E

We have some peaks; For all of them define a window in length of 7 around each and find the average over all points. See figure 5.

6   F

The previous result is shown in the figure 6 using the Display_Potential_3D function.

7   G

Using GainMat and averagePotentials matrices, solutions for MNE and wMNE have been found.

8   H

In this section, from the previous solutions, we find the maximum norm. Then find the index and corresponding location. MNE and wMNE specifications are shown in the figure 7.

9   I

We have the real location of the spiky dipole, we calculate the errors. See figure 8.
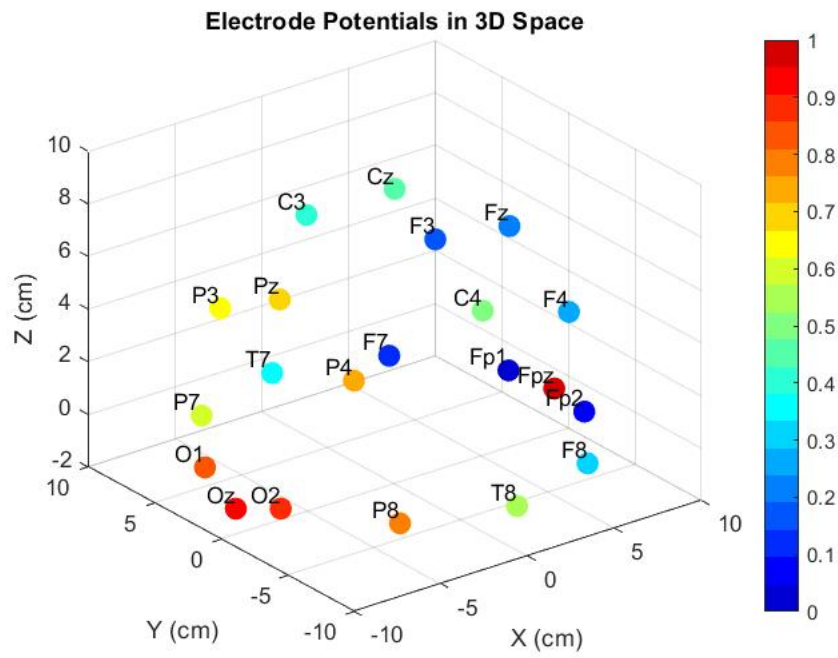
Figure 5: Average Potentials around peaks
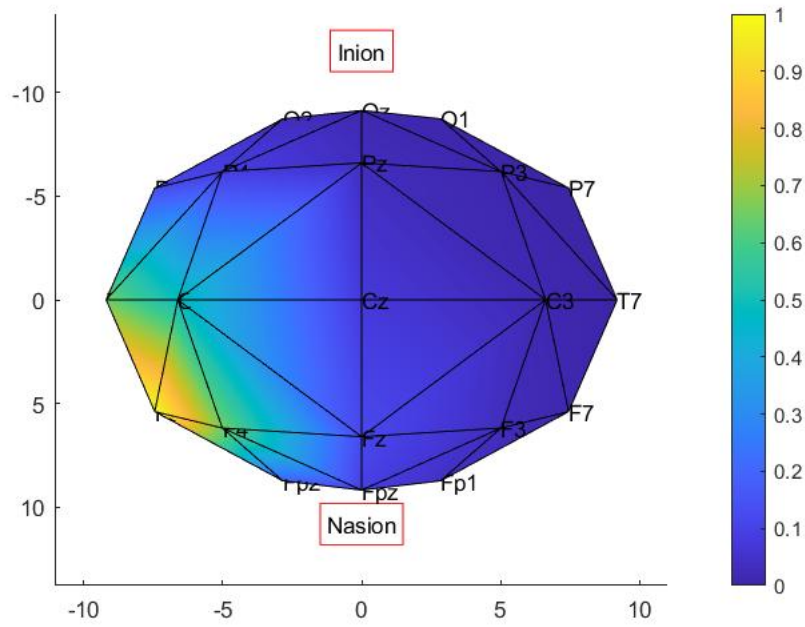

Figure 6: Average Using Display_Potential_3D

```
Command Window
  MNE Maximum Dipole Specifications:
  index:
      163
  norm:
      0.1005
  location:
      5.0000
     -6.0000
     -0.8000
  direction:
     -0.0013
     -0.0903
      0.0440
  wMNE Maximum Dipole Specifications:
  index:
      176
  norm:
      0.0509
  location:
      6.0000
     -5.0000
     -0.8000
  direction:
     -0.0136
     -0.0415
      0.0065
```

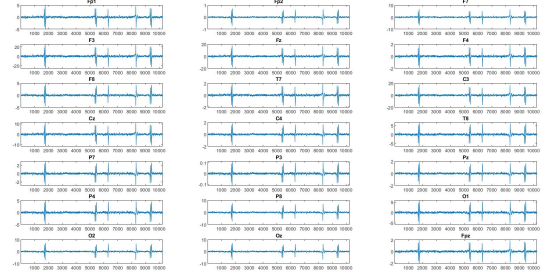Figure 7: MNE and wMNE Specifications


```
Command Window
  MNE Maximum Dipole Error:
  distance error:
      3.7417
  direction error:
      84.7511
  wMNE Maximum Dipole Error:
  distance error:
      4.6904
  direction error:
      88.0923
fx >>
```
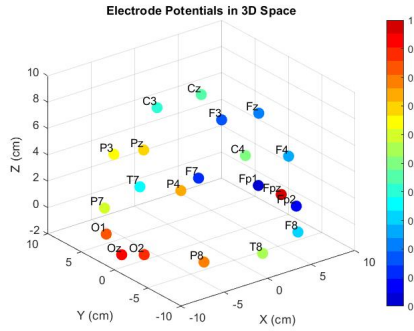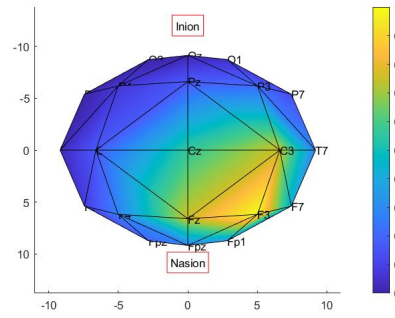
Figure 8: MNE and wMNE Errors
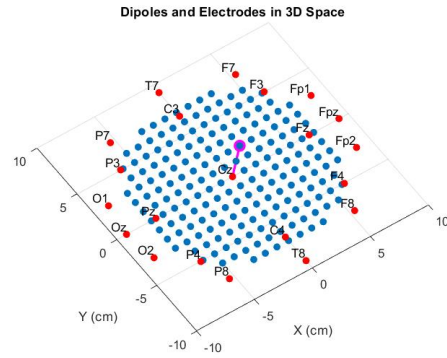
(a) 3D location

(b) Electrode Potentials

(c) Average Potentials

(d) Display_Potential_3D

(e) Specifications

(f) Errors

Figure 9: Deep Dipole Results

10   J

All previous results are shown in the figure 9.

11   K

Loreta and sLoreta methods have been chosen. See figure 10.

(a) loreta

(b) sloreta

(c) Errors

Figure 10: Tho Other Inverse Methods

Figure 11: Music Peaks

```
Command Window
    location_errors =
        1.0000
        2.0000
        6.6332
fx >>
```
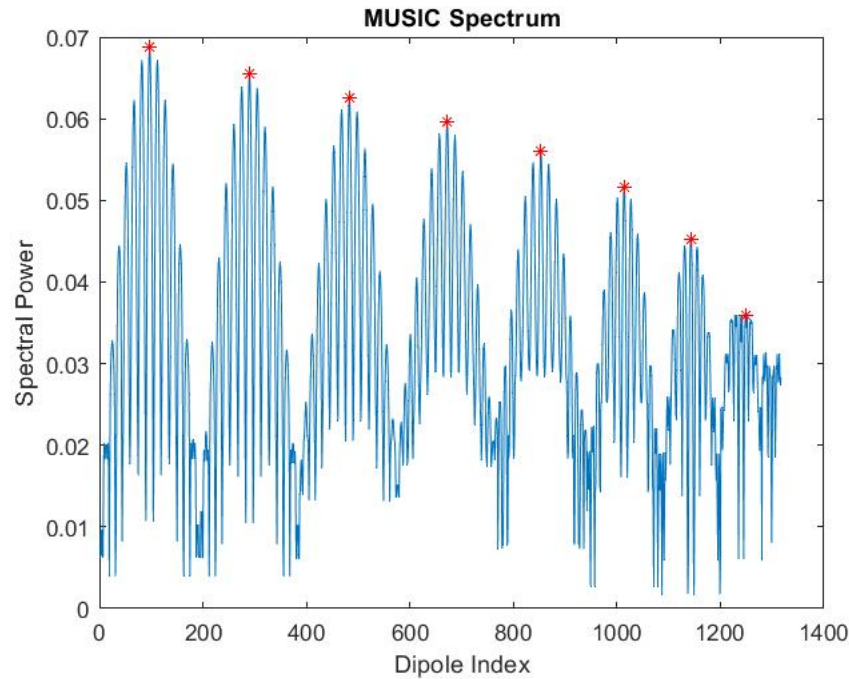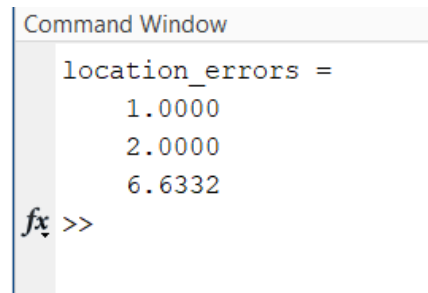
Figure 12: Location Error

12   L

The provided MATLAB code implements the MUSIC (MUltiple Signal Classification) algorithm, a popular parametric method used for source localization in EEG or MEG data. This algorithm operates by first computing the covariance matrix of the sensor data, followed by a Singular Value Decomposition (SVD) to separate the signal and noise subspaces. The core of the MUSIC algorithm involves scanning across potential source locations (dipoles) and calculating a spectrum that indicates the likelihood of a source being present at each location. This is achieved by measuring the orthogonality between the lead field of each dipole and the noise subspace—the peaks in this spectrum suggest the most probable source locations. The MUSIC algorithm is particularly noted for its high resolution and accuracy in localizing neural sources, especially in scenarios with a small number of active sources. See figure 11 & 12.
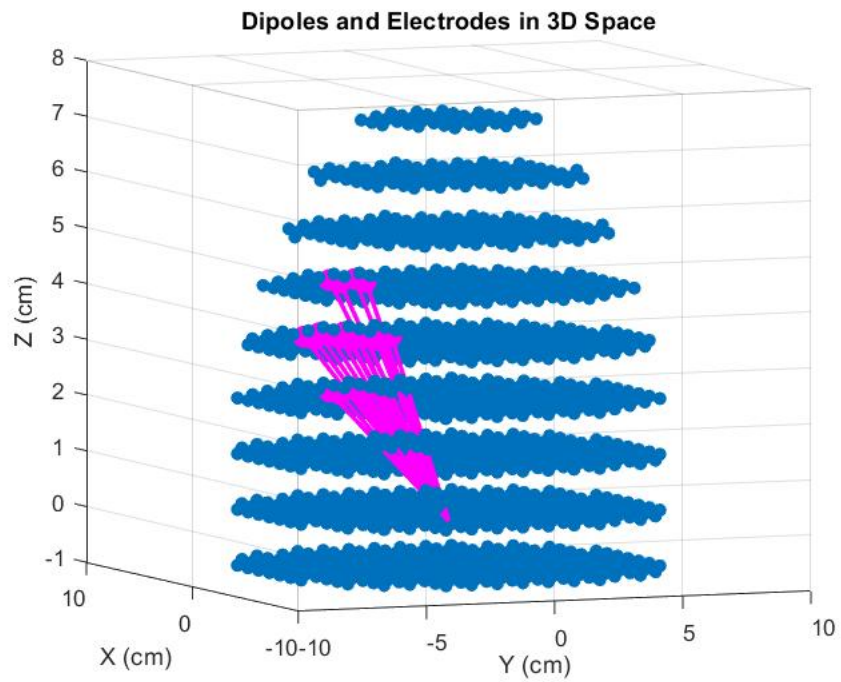
Figure 13: 20 Neighbors

13   M

We selected 20 instead of 15. See figure 13.

14   N
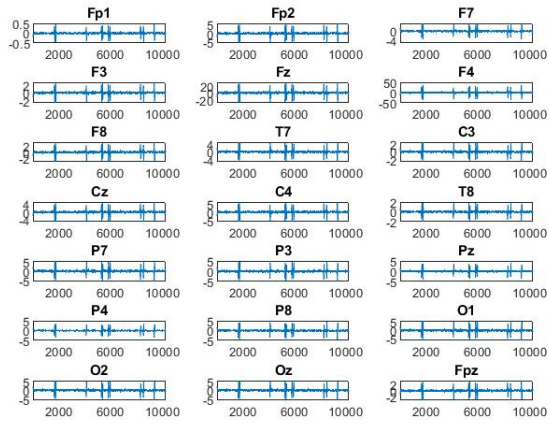
See figure 14.

15   O

Results have been obtained in the code.
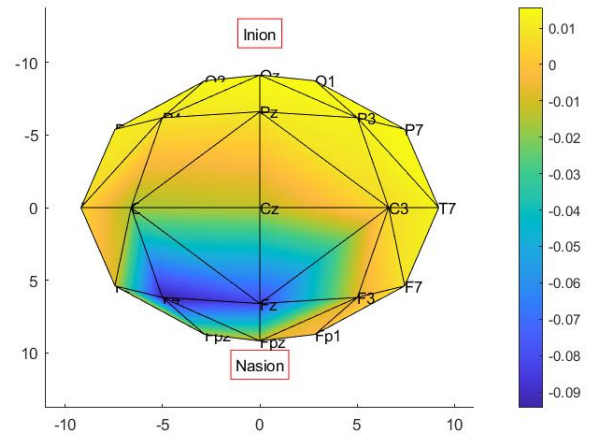
16   P

As considered dipoles are deep approximately, wMNE works better. See figure 15.

17   Q

We choose Loreta and sLoreta methods. See figure 16.

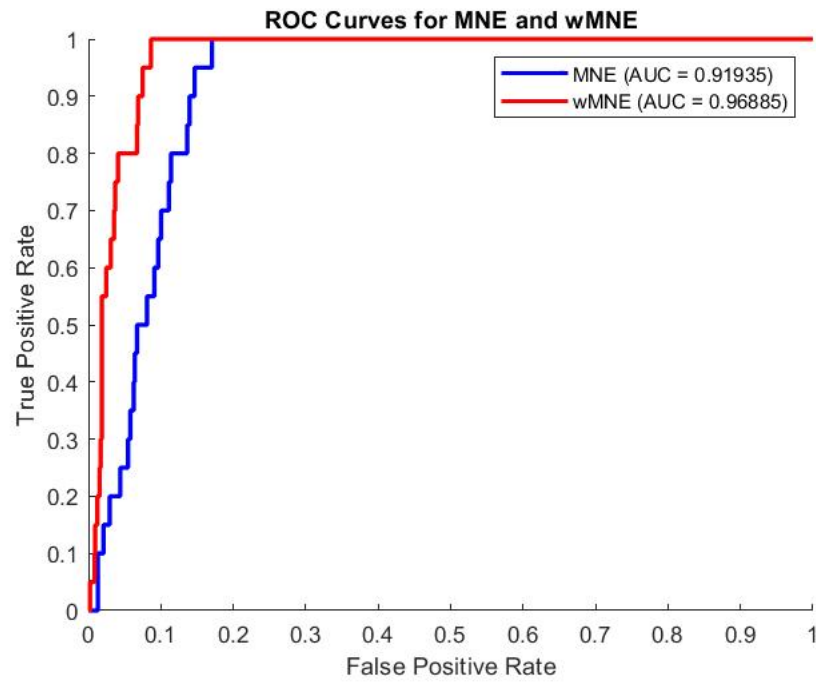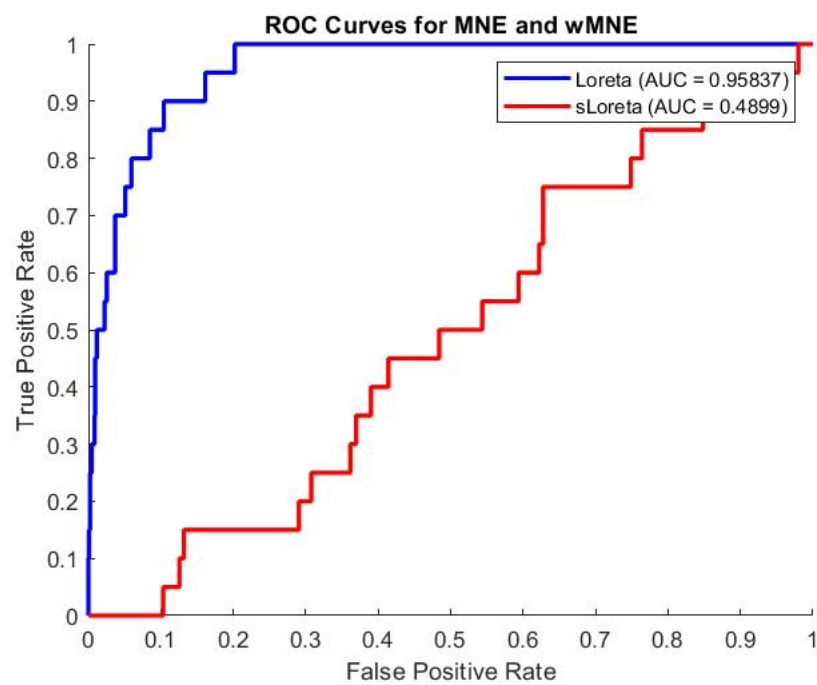(a) in time

(b) peaks

Figure 14: Neighbors Potentials

Figure 15: MNE & wMNE ROC

Figure 16: loreta & sLoreta ROC