Aim

To simulate EEG data at the dipole level and analyze the scalp-level responses using various signal and noise conditions.

Objectives

1. To load and visualize the brain dipole locations and their projections on the scalp.
2. To simulate pure sine wave signals in a dipole and explore amplitude effects.
3. To investigate the impact of noise on the dipole signals.
4. To simulate non-oscillatory transient signals and non-stationary oscillations in dipoles.
5. To analyze the scalp-level EEG responses under different signal and noise conditions.

Summary

This project involves simulating EEG data at the dipole level using MATLAB. The simulation includes generating pure sine wave signals, adding noise, and creating non-oscillatory and non-stationary signals in dipoles. The EEG data is then projected onto scalp electrodes to visualize and analyze the resulting signals. The project aims to understand the relationship between dipole-level signals and scalp-level EEG responses.

Tools and Libraries Used

- MATLAB
- Custom functions (e.g., plot_simEEG)
- EEG data structures
- MATLAB plotting functions

Procedure

1. **Load EEG Data:**

CODE:

```
load emptyEEG
```

Load the EEG data, leadfield matrix, and channel locations.

2. **Select and Plot Dipole Location:**

CODE:

```
diploc = 109;

figure(1), clf, subplot(121)

plot3(lf.GridLoc(:,1), lf.GridLoc(:,2), lf.GridLoc(:,3), 'bo','markerfacecolor','y')
```

hold on

plot3(lf.GridLoc(diploc,1), lf.GridLoc(diploc,2), lf.GridLoc(diploc,3), 'rs','markerfacecolor','k','markersize',10)

rotate3d on, axis square

title('Brain dipole locations')

Select a dipole location and plot the brain dipole locations.

3. **Project Dipole Signal to Scalp:**

CODE:

subplot(122)

topoplotIndie(-lf.Gain(:,1,diploc), EEG.chanlocs,'numcontour',0,'electrodes','numbers','shading','interp');

set(gca,'clim',[-1 1]*40)

title('Signal dipole projection')

Project the signal from the selected dipole to the scalp.

4. **Add Signal to Dipole and Project to Scalp Electrodes:**

CODE:

EEG.pnts = 2000;

EEG.times = (0:EEG.pnts-1)/EEG.srate;

dipole_data = zeros(size(lf.Gain,3),EEG.pnts);

dipole_data(diploc,:) = sin(2*pi*10*EEG.times);

EEG.data = squeeze(lf.Gain(:,1,:))*dipole_data;

plot_simEEG(EEG,31,2);

Add a sine wave signal to a dipole and project it to the scalp electrodes.

5. **Simulate Different Signal Conditions:**

    - **Pure Sine Wave with Amplitude Explorations:**

CODE:

EEG.trials = 40;

ampl = 1;

plot_simEEG(EEG,31,2);

Explore the amplitude of the dipole signal.

- **Sine Wave with Noise:**

CODE:

```
plot_simEEG(EEG,31,2);
```

Analyze the effect of noise on the sine wave signal.

- **Non-oscillatory Transient Signal:**

CODE:

```
plot_simEEG(EEG,31,2);
```

Simulate and visualize non-oscillatory transient signals.

- **Non-stationary Oscillation and Transient Oscillation:**

CODE:

```
plot_simEEG(EEG,56,3);
```

```
plot_simEEG(EEG,31,2);
```

Simulate non-stationary oscillations and transient oscillations in different dipoles.

Highlights

- **Signal Projection:** Using the leadfield matrix to project dipole signals to scalp electrodes.
- **Amplitude and Noise Analysis:** Exploring the effects of signal amplitude and noise on scalp-level EEG responses.
- **Non-stationary and Transient Signals:** Simulating complex signal conditions in dipoles and analyzing their impact.

Conclusion

The simulation of EEG data at the dipole level in MATLAB provides valuable insights into the relationship between dipole-level signals and scalp-level EEG responses. By experimenting with different signal and noise conditions, the project highlights the complexity and variability of EEG data, aiding in the understanding and interpretation of neural time series analysis.