Data Generation and Validation

NOTICE

Regretably real LFP and Spiking data has rules behind it, and we have not been able to that we can use all of it yet. We do however have a general idea of what the data looks like. Below are the methods used to generate some data to confirm that our `spike_inference` program works on data of the same shape.

- *Leonardo Ferrisi*

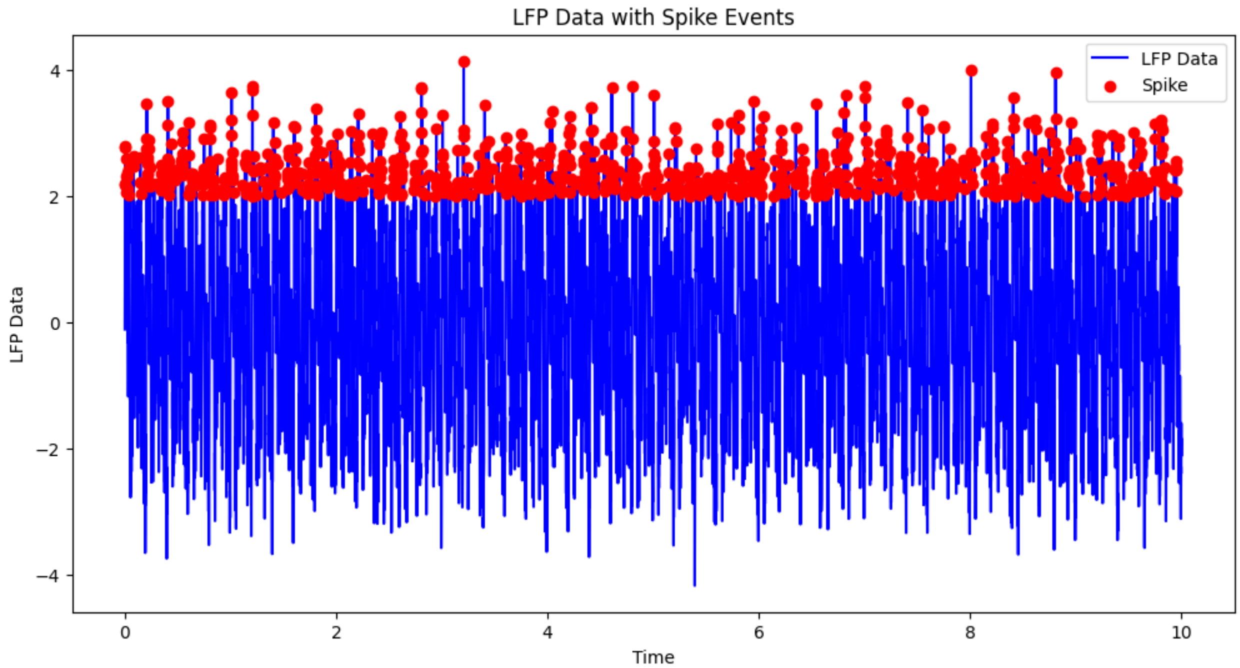
```
# Imports
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

# Generate Simulated LFP Data and Spikes
# Parameters for the fake LFP signal
duration      = 10          # Duration in seconds
sampling_rate = 1000   # Sampling rate in Hz (samples per second)
num_samples   = duration * sampling_rate
time          = np.linspace(0, duration, num_samples, endpoint=False)

# Frequencies to include in the LFP signal
freqs         = [10, 15, 30, 55]

# Generate the LFP signal as the sum of multiple sine waves
lfp = np.zeros_like(time)
for freq in freqs:
    lfp += np.sin(2 * np.pi * freq * time)

# Optionally, you could average the sine waves:
# lfp = lfp / len(freqs)

# Add Gaussian noise to simulate real-world conditions
noise_std = 0.5  # Standard deviation of the noise
lfp += np.random.normal(0, noise_std, size=num_samples)

# Simulate spike events: mark spike=1 when the LFP exceeds a
threshold.
# Adjust the threshold based on the expected amplitude of the LFP.
spike_threshold = 2.0
spike = (lfp > spike_threshold).astype(int)

# Create a DataFrame with the time, LFP signal, and spike events
df = pd.DataFrame({
    'time': time,
    'lfp': lfp,
```

```
    'spike': spike
})

# Write the DataFrame to a CSV file
output_filename = 'data_gen_test.csv'
df.to_csv(output_filename, index=False)
print(f"Fake LFP data saved to {output_filename}")
```

```
Fake LFP data saved to data_gen_test.csv
```

```
# Plotting the Data
# Each spike is marked as a red dot on the plot
# The LFP data is very noisy, but you can see the spikes clearly

# Load the CSV data
df = pd.read_csv("data_gen_test.csv")

# Clean the column names (if necessary)
df.columns = df.columns.str.strip().str.lower()

# Verify columns
print("Columns:", df.columns.tolist())

# Create the plot
plt.figure(figsize=(12, 6))

# Plot the lfp_data over time
plt.plot(df['time'], df['lfp'], label='LFP Data', color='blue')

# Overlay spike events (assuming spike is stored as a boolean or 0/1)
spike_mask = df['spike'] == True  # or df['spike'] == 1 if spikes are marked as 1
plt.scatter(df.loc[spike_mask, 'time'], df.loc[spike_mask, 'lfp'],
            color='red', label='Spike', zorder=5)

# Label the axes and add a title
plt.xlabel("Time")
plt.ylabel("LFP Data")
plt.title("LFP Data with Spike Events")
plt.legend()

# Show the plot
plt.show()
```

```
Columns: ['time', 'lfp', 'spike']
```




```
# FFT for further validation

# Load the CSV data
df = pd.read_csv("data_gen_test.csv")
# Clean column names if needed
df.columns = df.columns.str.strip().str.lower()  # makes them
lowercase and strips whitespace

# Extract time and LFP data
time = df['time']
lfp = df['lfp']

# Calculate the sampling interval (assuming time is uniformly spaced)
dt = np.mean(np.diff(time))
fs = 1 / dt  # sampling frequency

# Compute FFT
n = len(lfp)
fft_result = np.fft.fft(lfp)
freq = np.fft.fftfreq(n, d=dt)

# For plotting, take only the positive frequencies
mask = freq > 0
freq_pos = freq[mask]
fft_amplitude = np.abs(fft_result[mask])

# Plot the FFT amplitude spectrum
plt.figure(figsize=(12, 6))
plt.plot(freq_pos, fft_amplitude, color='green')
```

```
plt.xlabel("Frequency (Hz)")
plt.ylabel("Amplitude")
plt.title("FFT of LFP Data")
plt.grid(True)
plt.show()
```