Temporal Time Series Analysis

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Background

- Last Spring 2023 I helped in the discussion sessions of this course.
- Suggested to Klara Olofsdotter (SWC PhD program coordinator) and Sonja Hofer (SWC PhD program faculty coordinator) to ask SWC PhD students to take this course. They liked the idea.
- I volunteered to lead discussions and do grading with Gatsby Unit PhD students and postdoctoral scholars.

A few motivations to run this course

1. Gain more teaching experience.
2. Provide SWC PhD students with essential neural data-analysis tools.
3. Contribute to better interactions between the SWC and the Gatsby Unit.

Course structure

Week 01	Jan 11	The t-test and randomisation tests	Joaquin Rapela	tutorial
Week 02	Jan 18	Power spectra	Joaquin Rapela Yousef Mohammadi Joe Zimminski	tutorial
Week 03	Jan 25	Spectrograms and coherence	Joaquin Rapela Yousef Mohammadi Joe Zimminski	tutorial
Week 04	Feb 01	Circular statistics	Joaquin Rapela	tutorial
Week 05	Feb 08	Singular value decomposition	Will Dorrell	tutorial
Week 06	Feb 15 Feb 16	Linear regression	Lior Fox	lecture tutorial
Week 07	Feb 22 Feb 23	Linear dynamical systems	Aniruddh Galgali Joaquin Rapela	lecture tutorial
Week 08	Feb 29	no class (CoSyNe)		
Week 09	Mar 07 Mar 08	Artificial neural networks	Erin Grant	lecture tutorial
Week 10	Mar 14 Mar 15	Experimental control with Bonsai	Goncalo Lopes Joaquin Rapela	lecture tutorial
Week 11	Mar 21 Mar 22	Reinforcement learning		lecture tutorial
Week 12 Week 15	Mar 28 Apr 25	Project development		
Week 16	May 02	Project presentations		

Teaching assistants: Kira Dusterwald, Sihao (Daniel) Liu

Graded worksheets

Every Thursday we will assign you a worksheet that is due on the second Monday after the assignment.

Contents

What is time series analysis?

- Time series analysis characterizes **data that is correlated in time**.
- These correlations serverly **restrict the applicability of conventional techniques** assuming data samples that are independent and identically distributed.
- These correlations allow to **forecast** future values of a time series based on present and past values.

Relevance of time series analysis

economics	daily stock market quotations, monthly unemployment figures.
social scientists	birthrates, school enrollment.
epidemology	number of influenza cases observed over some time period.
medicine	blood pressure measurements traced over time.

Temporal vs spectral time series analysis

termporal time series analysis focuses on the analysis of lagged relationship (e.g., how does what happened today affect what will happen tomorrow?).

spectral time series analysis centers on the analysis of rhythms (e.g., can we observe rhythmic activity in local field potentials recorded from human brains?)

An example time series

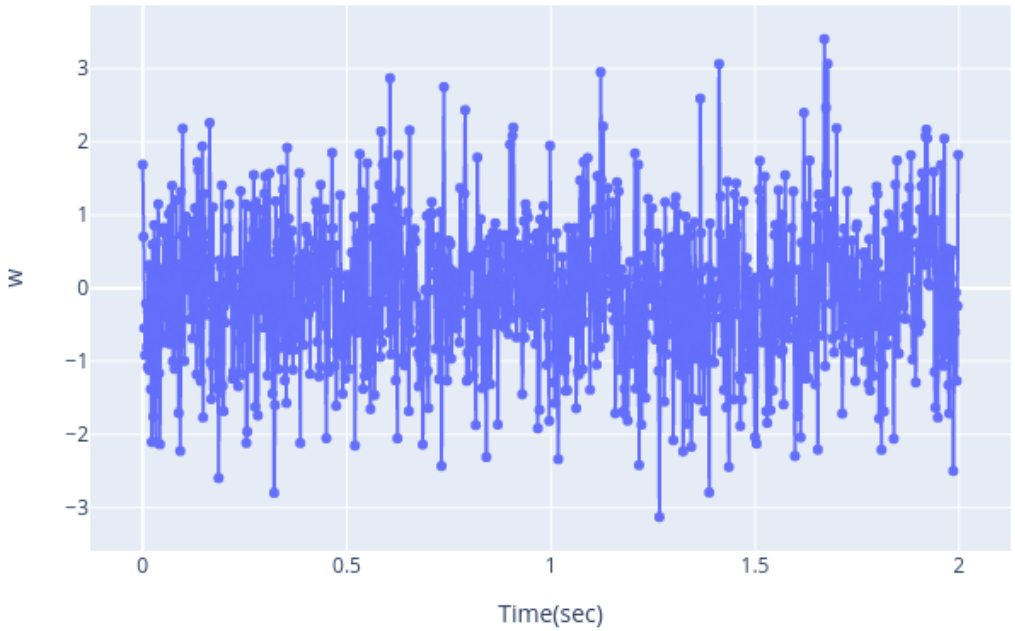
In the examples below we will use spontaneous EEG (i.e., no task) recorded from a human subject (Liu et al., 2024).

Generation of time series: white noise

The first step to generate time series is to generate **white noise** (i.e., independent Gaussian random variables with zero mean and fixed variance).

```
w = np.random.normal(loc=0, scale=sigma, size=N)
```

Example



Generation of time series: moving average

moving average models

$$\nu_t = \frac{1}{3}(w_{t-1} + w_t + w_{t+1})$$

autoregressive models

$$x_t = x_{t-1} - 0.9x_{t-2} + w_t$$

random walk with drift

$$x_t = \delta + x_{t-1} + w_t$$

signal plus noise

$$x_t = \delta + x_{t-1} + w_t$$

Summary

Liu, Q., Jia, S., Tu, N., Zhao, T., Lyu, Q., Liu, Y., Song, X., Wang, S., Zhang, W., Xiong, F., et al. (2024). Open access eeg dataset of repeated measurements from a single subject for microstate analysis. *Scientific Data*, 11(1):379.