Foundation models *for spatial-time series*

Week 4

Themes for talks and essays

1. Neural ODE, Controlled ODE (continuous flows, Hamiltonian NN)
2. Neural PDE for classic equations
3. Neural PDE for Maxwell equations
4. Navier-Stokes and non-linear models
5. Galerkin Neural Networks (and Green functions)
6. State space models S4, S5, Hippo et al.
7. Graph diffusion and GRANT
8. Operator learning for spatial time series
9. Riemannian models and forecasting
10. CCM for continuous time (and space)
11. Spectral Submanifolds (and machine learning)
12. Tensor models for continuous spatial-time series

*** Continuous spatial-time Kalman filters

*** Spherical harmonic / Spinor models

*** Generative models for spatial time series

Initial models

1. Models
    a. Direct models: AR, ARIMA, GRU, LSTM
    b. Metric models: LLE, DM, GH, RBF
    c. Non-parametric: GPR
2. Ways to construct state spaces
    a. SSM models: S4, S5, Hippo
    b. Kalman
    c. SSA, SSM
3. Ways to transform state spaces
    a. FT, OL, ODE
    b. CCA, CCM

The time series has two domains: the time domain and the frequency domain. The spatial time series also has a metric space or metric tensor that changes in time.

Requirements for the text and the discussion

1. Comprehensive explanation of the method or the question we discuss
2. **Convey the principle**
3. Two-page text (more or less)
4. The reader is a second or third-year student
5. The picture is obligatory
6. However, a brief reference to some deep learning structure is welcome
7. The talk could be slides or a text itself
8. The list of references with doi
9. Observing a gap, put a note about it (to question later)
10. **The code to wrap to your foundation model is obligatory, check if it works**

Assumptions on the time series

1. There is a set of time series
2. This set is carried by a single timeline
3. This set is declared as a spatial time series
4. There is a relation between time series expressed by a metric tensor
5. Time series transforms to its phase trajectory
6. We forecast targets $y_{t+1} = f(x_t, y_t)$ there are two different phase spaces: for x and for y
7. There is a context of time series, unchanged in time

The future code with datasets

Datasets: any that fit the assumptions below

Models: any model mentioning the interface of FM-wrappers

Context: for data and the models

1. BNCI Horizon 2020: open access BCI data sets
2. Climate Prediction Center: wind, sea level, and sea temperature for years
3. NFDA Book time series: satellite, spectrometric, phoneme, electricity consumption, El Niño