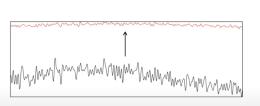# Project 1

## Plan

- **Title:** Spatial time series reconstruction using structured state spaces (S4)

- **Problem:** Consider spatial time-series signal $\mathbf{X} \in \mathbb{R}^{E \times N}$. Find Optimal state space $\mathbf{x}$ that has best reconstructs $\mathbf{X}'$ (in terms of reconstruction loss).

- **Data:** Any of the available EEG datasets, e.g. PhysionetMI

- **Base solution:** take existing baselines for reconstruction

- **Proposed solution:** Use S4 layer as the building block of the seq2seq models.

- **Novelty:** Novelty to be clarified, but S4 layers have recently appeared and there are few studies that have examined them for EEG

# Structured State Spaces (S4)

SSM + **HiPPO** + Structured Matrices = **S4**

Plug in the HiPPO matrix

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 2 & 0 & 0 \\ 1 & 3 & 3 & 0 \\ 1 & 3 & 5 & 4 \end{bmatrix}$$

$$x' = \boldsymbol{A}x + \boldsymbol{B}u$$
$$y = \boldsymbol{C}x + \boldsymbol{D}u$$

HiPPO

# Deep S4 for General Sequence Modeling



(batch, length, dim)

Linear

S4

Normalization

(batch, length, dim)

**Multi-dimensional** input: S4 per channel
(similar to **depthwise-separable** CNN)