Time Series Classification (TSC) for EEG

Objective:

- Apply time series classification to multivariate EEG recordings.
- Build a working classification model using short signal windows.

Focus Areas:

- Implement the **ROCKET** and **MiniROCKET** methods.
- Use standard evaluation metrics (accuracy, time, robustness, etc.).
- Explore generalization across subjects and performance adaptation.

Motivation:

- EEG as multivariate time series.
- Efficient, accurate, and interpretable models are needed for real-time applications.

Core Methods & Research Foundations

Key Papers & Approaches:

- **Are EEG Sequences Time Series?**
    - Compares traditional EEG methods vs. generic TSC models.
    - Investigates subject-specific, agnostic, and conditional training.
- **ROCKET (Random Convolutional Kernels):**
    - Fast and simple classifier using random convolution kernels.
    - Ideal for short EEG windows.
- **MiniROCKET:**
    - Lightweight, faster ROCKET variant.

Advanced Variants of ROCKET

Newer Innovations:

- **Detach-ROCKET Ensemble:**
  - Ensemble + pruning technique.
  - Improves accuracy & interpretability in high-dimensional EEG data.
- **Multi-scale ROCKET (for Inter-burst Detection):**
  - Combines high/low-frequency components for detecting patterns in preterm EEG.

HDC-MiniROCKET:

- Combines MiniROCKET with Hyperdimensional Computing.
- Explicitly encodes temporal dependencies.

S-ROCKET:

- Selects most informative kernels.
- Reduces redundancy, increases efficiency.

Suggested Implementation Plan

1. MiniROCKET Baseline

- Fast, accurate, efficient.
- Start with implementation and benchmarking.

2. Public EEG Dataset

- Example: BCI Competition IV dataset.
- Preprocessing and windowing for TSC.

3. Explore Variants

- HDC-MiniROCKET for time-dependency handling.
- S-ROCKET for improved kernel selection.

Evaluation & Comparative Analysis

Comparative Metrics:

- **Generalization Across Subjects:**
    - How well do models perform with minimal training data?
- **Data Efficiency / Few-shot Learning:**
    - Can the model learn from limited data?
- **Interpretability & Explainability:**
    - Are the model decisions transparent?

Computation & Noise Robustness:

- Speed and tolerance to signal noise.

Prediction Stability:

- Consistency across trials and signal variations.