# AI model training and deployment on sleep EEG data

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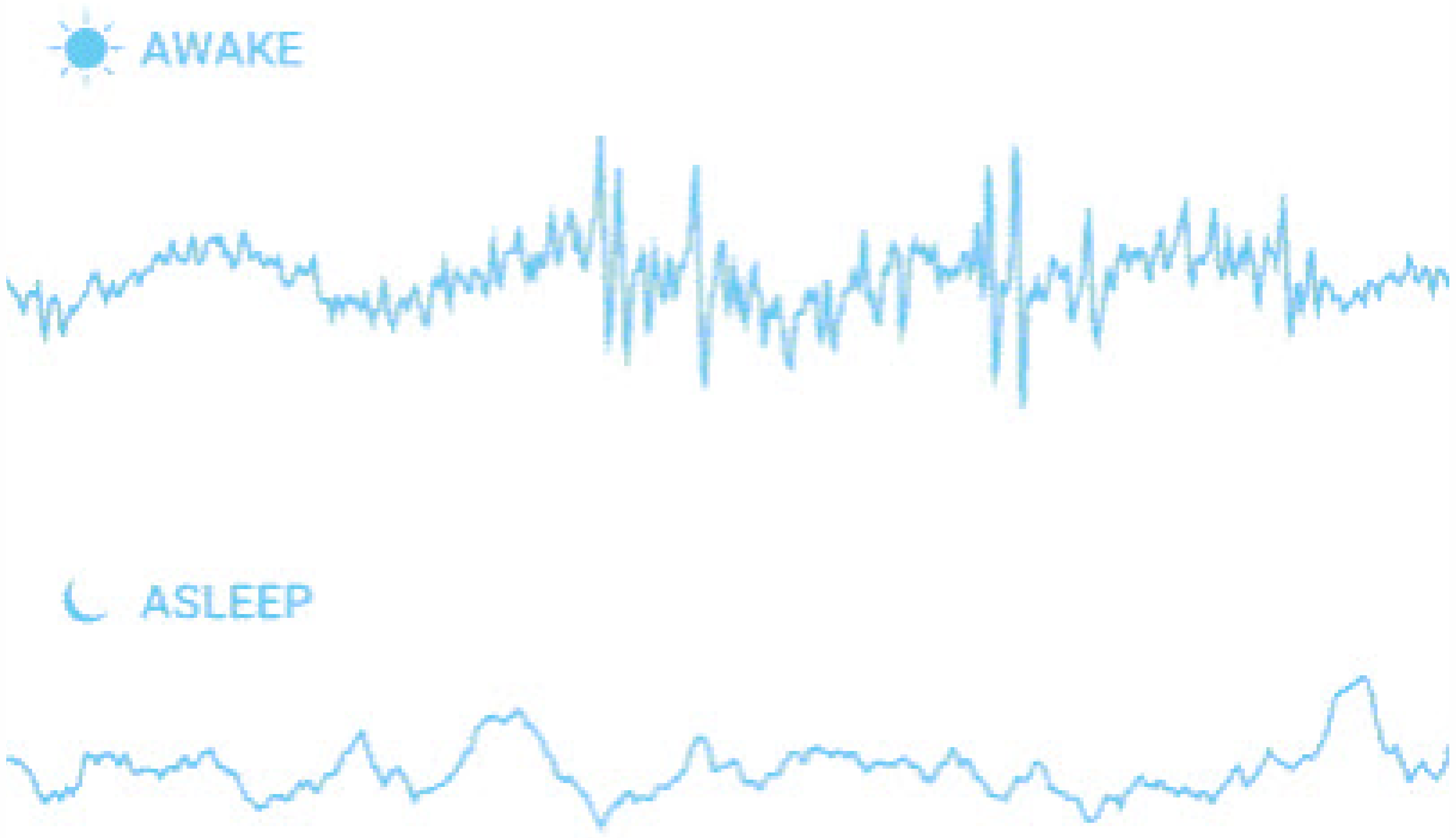
# Introduction

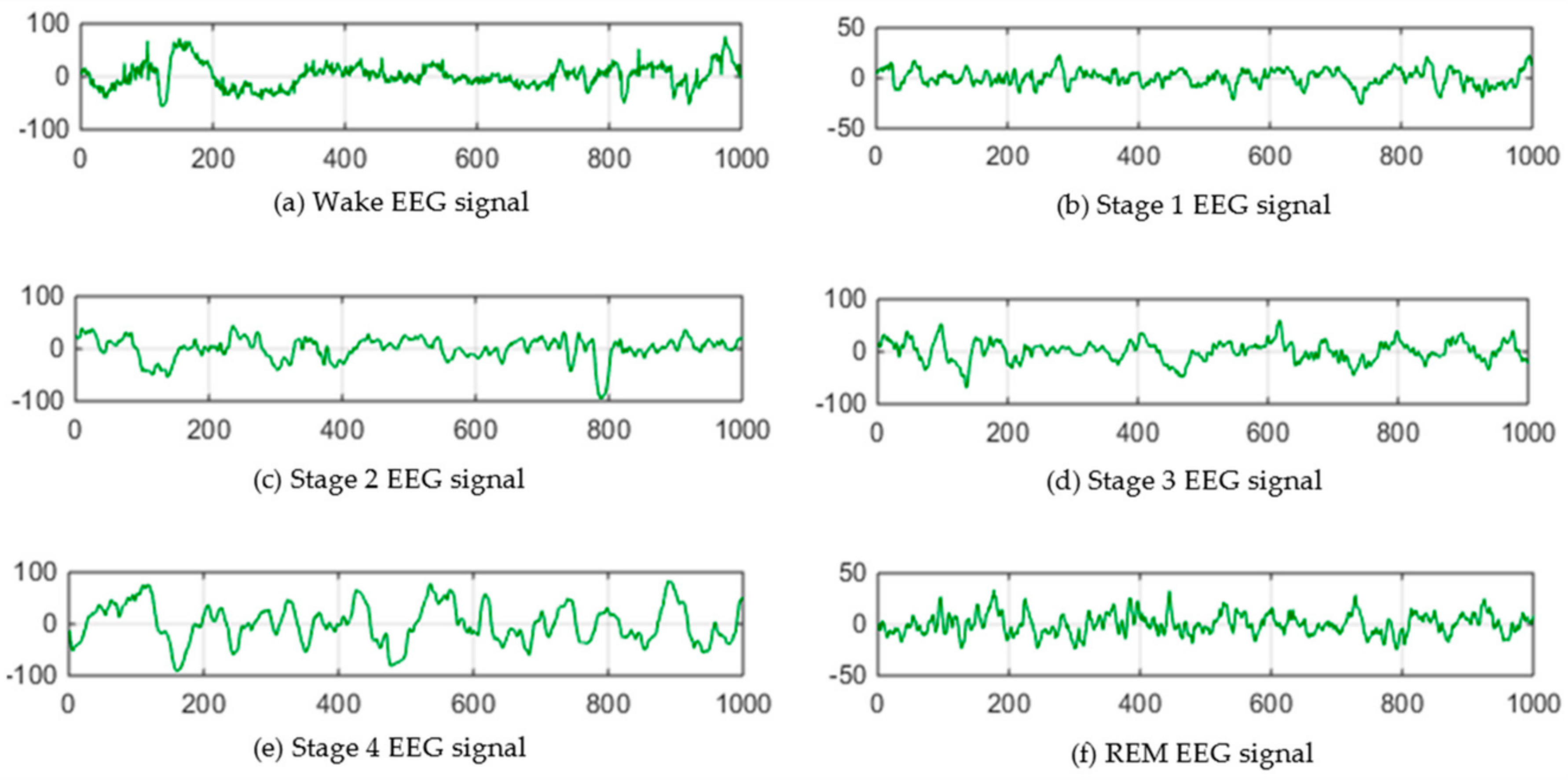
Sleep EEG is a recording of the brain's electrical activity during sleep. It is commonly used to diagnose sleep disorders and monitor the effectiveness of treatment.




Automatic sleep stage scoring analyses the physiological signals collected during sleep and classifies each 30-second epoch of sleep into one of the five standard sleep stages:
wake, non-REM stage 1, non-REM stage 2, non-REM stage 3, and REM (rapid eye movement) sleep.

# Deep Learning Model for Sleep Stage Scoring

Recently, deep learning has become popular for automatic sleep stage scoring due to its capability to extract useful features from raw signals automatically, making the process of hand-engineering features no longer necessary.



(a) Wake EEG signal

(b) Stage 1 EEG signal

(c) Stage 2 EEG signal

(d) Stage 3 EEG signal

(e) Stage 4 EEG signal

(f) REM EEG signal

Our model takes in N EEG epochs from a single-channel EEG signal, where each epoch has a duration of 30 seconds. The model produces N predicted sleep stages {y1, . . . , yN } corresponding to the five sleep stages W, N1, N2, N3 and REM, with y being the predicted sleep stage of each epoch. The model is trained to determine these sleep stages for all epochs.

# Dataset

Our model uses seven public sleep datasets obtained from  Sleep-EDF-v1 Database. These datasets have been collected in different environments and annotated with different sleep manuals, which can be used to demonstrate the generalisability of the model. The dataset was published in 2013, in which there are 39 PSG recordings from the SC study, collected from 20 subjects.
The provided sleep EEG time series data represents the electrical activity of the brain during sleep, which is recorded using an electroencephalogram (EEG). The data is organized into columns, with each row representing a single time point in the recording.

The data file corresponding to each subject has the following columns:

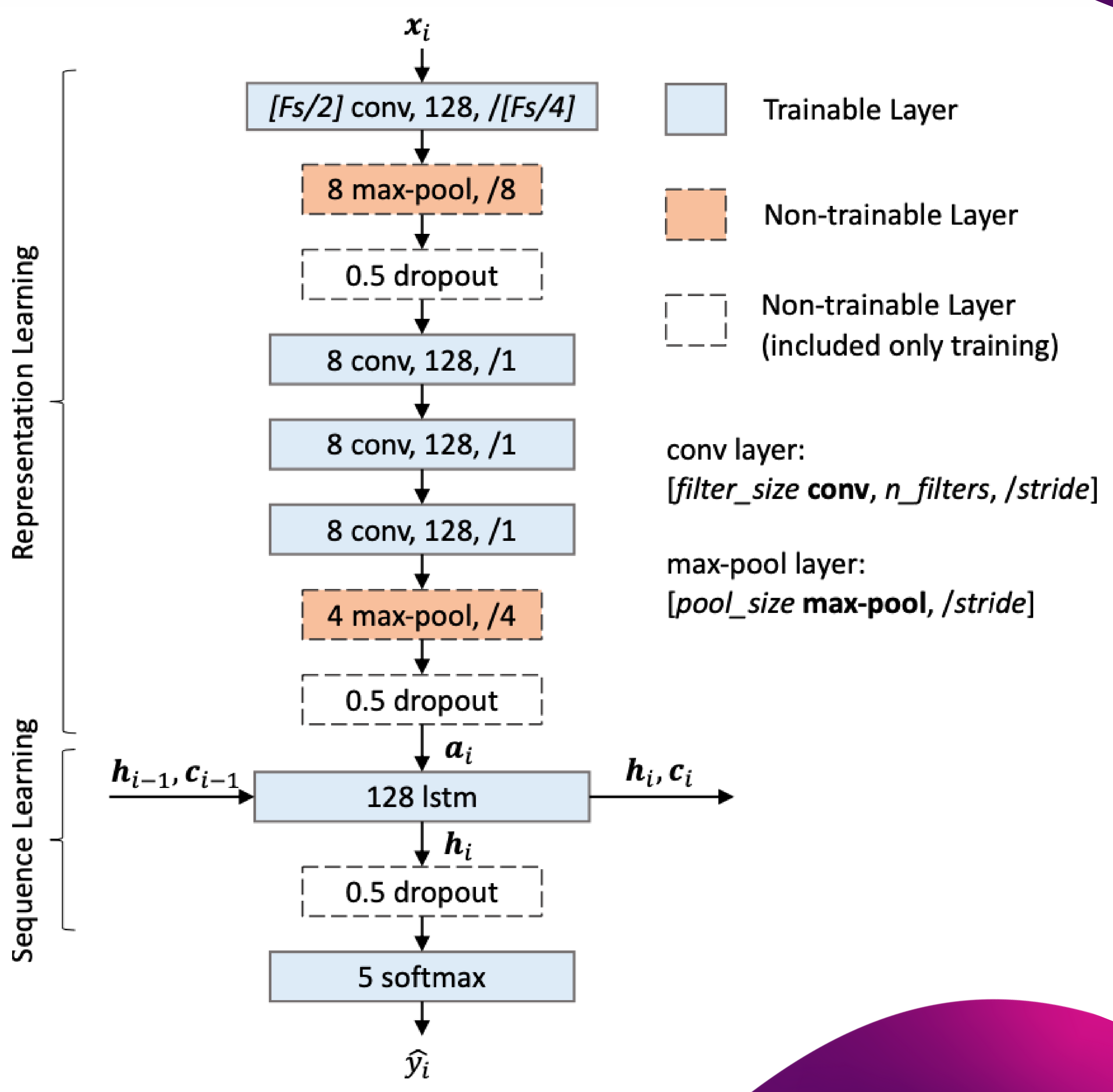
x - Amplitude of electrical activity produced by the neurons in the brain
y -  sleep stage label of each x
fs - Sampling rate: 100Hz
ch_label - Channel Label: EEG Fpz-Cz
start_datetime; epoch_duration; n_all_epochs; n_epochs

# Model architecture

Our model is divided into 2 parts representation learning and sequence learning.

The first part of the network close to the input signals is CNNs. The CNNs consist of four convolutional layers, interleaved with two max-pooling and two dropout layers. This part is used to extract time-invariant features from raw EEG signals.

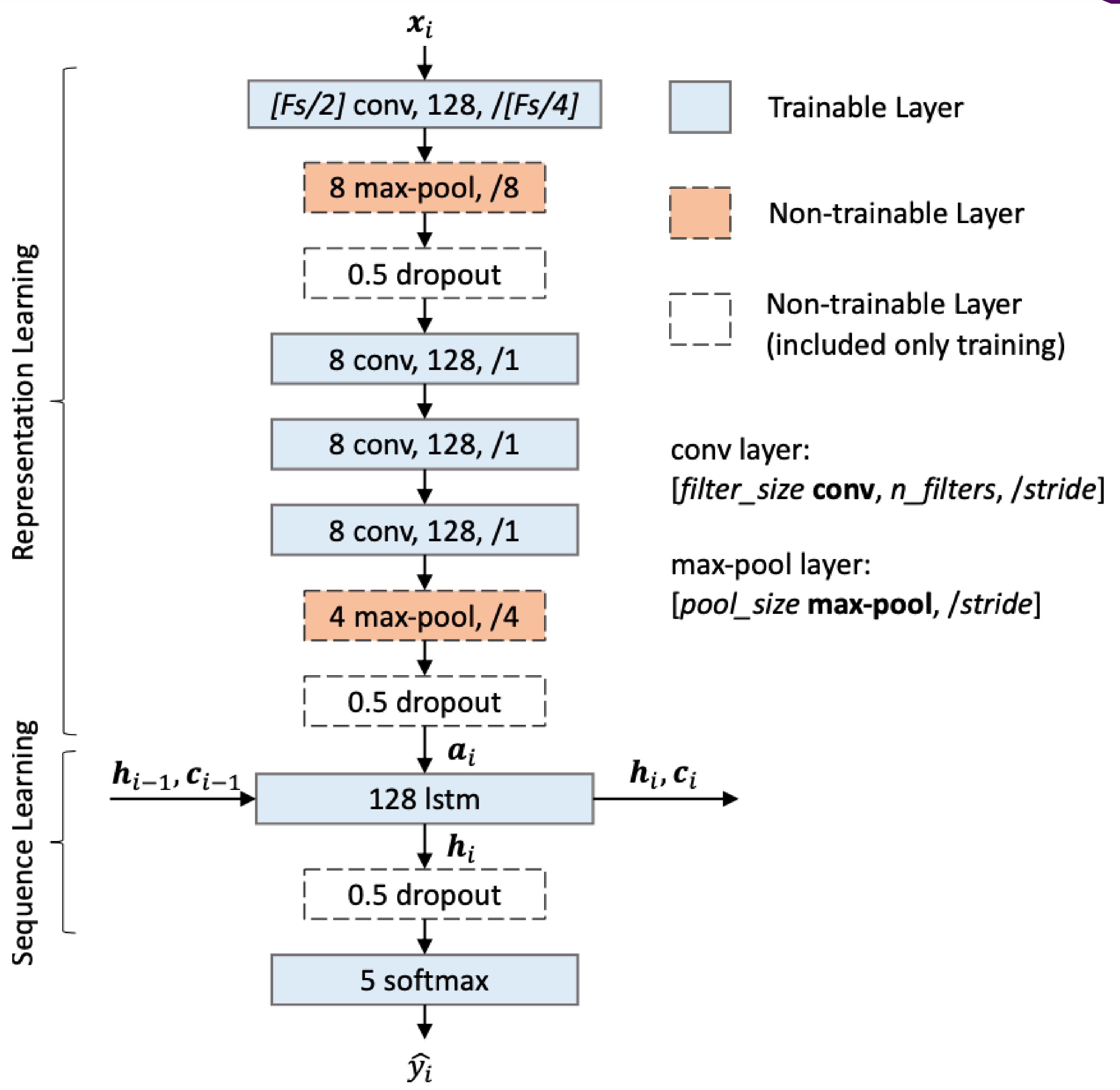
We applied a convolutional neural network (CNN) on the raw EEG signals to extract important features, such as spectral power in certain frequency bands, coherence between different EEG channels, or other measures of EEG signal complexity or organization.



# Sequence Learning

The second part of the network close to the output sleep stages is a unidirectional RNNs, consisting of a single LSTM layer followed by a dropout layer.

This part is used to learn the temporal information of the input signals, such as sleep transition rules that sleep experts use to determine the next possible sleep stages based on the previous stages.



# Model Training and Data Augmentation

Our technique trains the model end-to-end via minibatch gradient descent, equipped with what is called, **signal and sequence augmentation.** Such data augmentation helps us to synthesise new training data from the original data for every training epoch.

To address the class imbalance problem, the weighted **cross-entropy loss** is used, which assigns a weight of 1.5 to the N1 stage and 1 to the other stages and trained the model using the **Adam optimiser** with a learning rate of 0.001.

They used a batch size of 64 and trained the model for 200 epochs. The model was evaluated using the **Cohen's kappa coefficient metric.**

# Results after training of model

W: 10197
N1: 2804
N2: 17799
N3: 5703
REM: 7717
Total: 44220

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Confusion Matrix
[[ 9095   861   103    22   116]
 [  421  1585   554    11   233]
 [  416   538 15633   536   676]
 [   51     7   784  4859     2]
 [  166   598   781     4  6168]]
```

### Results Obtained

Accuracy: 84.4
Macro F1-Score: 79.3
Per-class F1-Score: 89.4 49.6 87.7 87.3 82.7

### Results Claimed

Accuracy: 85.4
Macro F1-Score: 80.5
Per-class F1-Score: 90.1 51.4 88.5 88.3 84.3

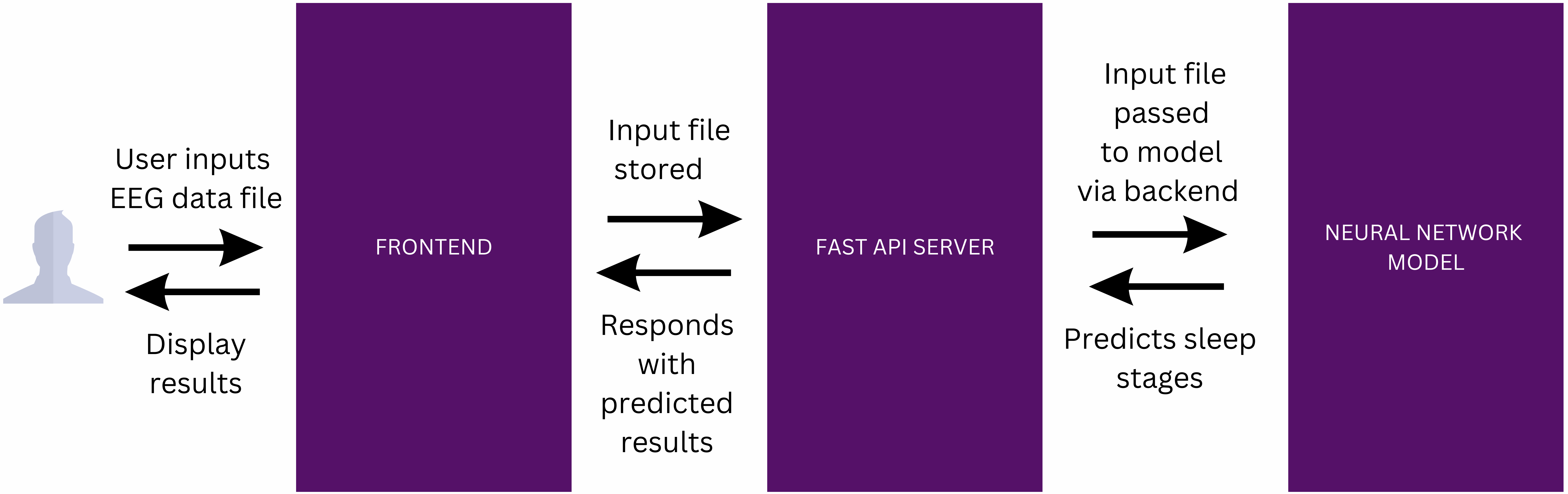
# Web Application and Tech Stack Used

Our model has been successfully deployed and is ready for use on the web app, which involves making the front end on REACT JS and using the FastAPI framework in Python as backend to run the model to predict the stages.

**Frontend on REACT JS:** We used REACT JS to create a user-friendly interface for users to input files containing EEG data in .npz format and then display predicted sleep stages.

**Backend using FastAPI:** We have used FastAPI as the backend for our model. It handles the user input, pass it to the model for prediction, and returns the predicted sleep stages to the front end.

# Flowchart




Here's a short demo for you!

# Related Work

1. Supratak, Akara, and Yike Guo. "TinySleepNet: An efficient deep learning model for sleep stage scoring based on raw single-channel EEG." 2020 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC). IEEE, 2020.
2. Supratak, Akara, et al. "DeepSleepNet: A model for automatic sleep stage scoring based on raw single-channel EEG." IEEE Transactions on Neural Systems and Rehabilitation Engineering 25.11 (2017): 1998-2008.

# Contributions

- Model Training and Prediction: Dhruv, Naval
- Front End: Naval, Siddharth
- FastAPI Back End: Siddharth, Dhruv
- Other work: Siddharth, Naval, Dhruv

# ThankYou