

Journal Club

Yihui Du

07.22.2020

What I have done by now



➤ Paper Reading

- ❖ Robust, automated sleep scoring by a compact neural network with distributional shift correction.
- ❖ SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.

➤ Software & Hardware Coding

- ❖ Matlab codes for automated real-time sleep scoring
- ❖ Arduino codes for controlling the singlechips to manipulate stimulus signal

Robust, automated sleep scoring by a compact neural network with distributional shift correction.

- ❖ **Background**
- ❖ **Distributional shift correction**
- ❖ **Automated sleep scoring by neural network**
- ❖ **AccuSleep interface for sleep scoring**

Robust, automated sleep scoring by a compact neural network with distributional shift correction.

❖ Background

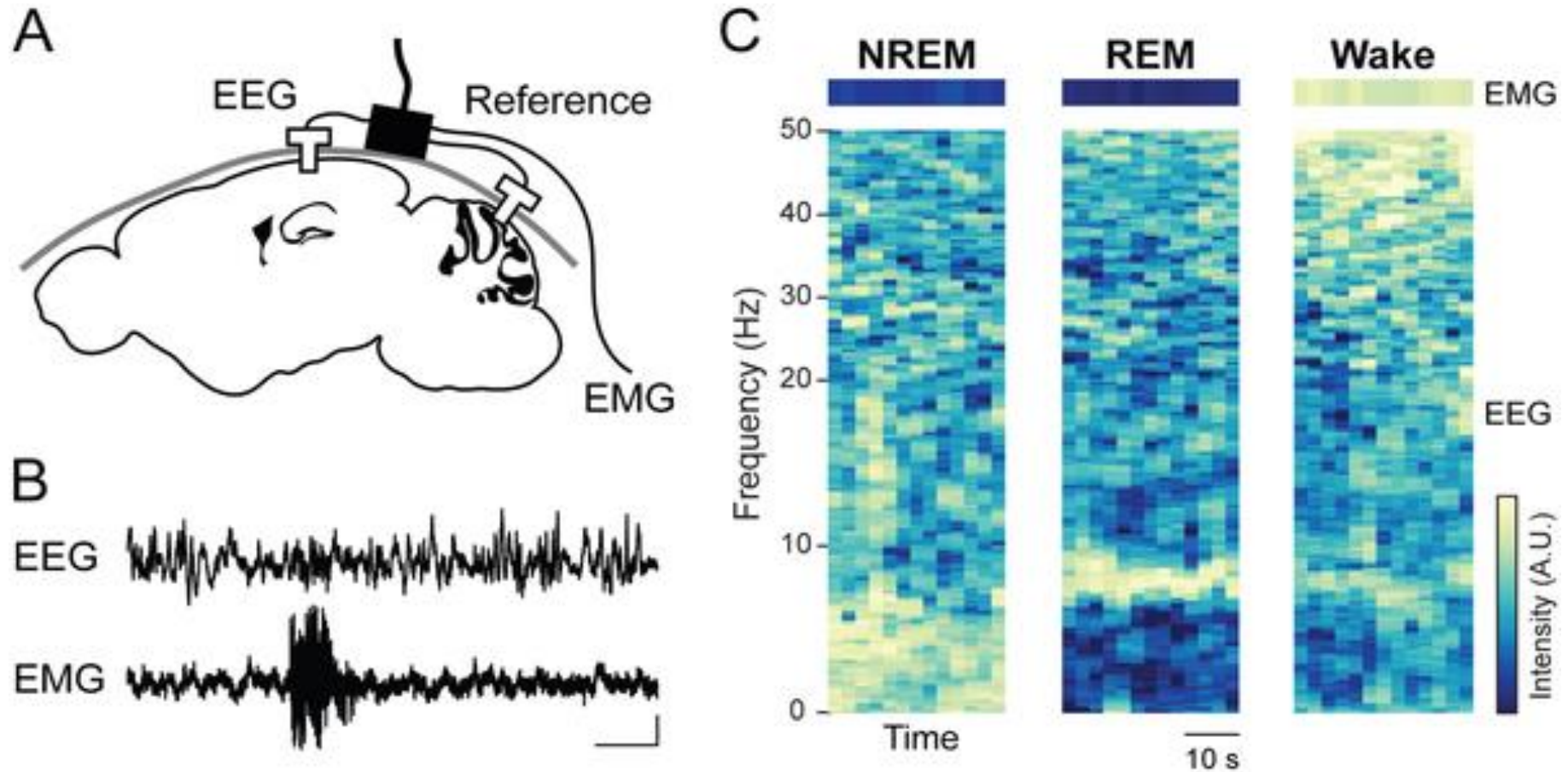


Fig 1. Overview of the signal collection process for sleep scoring in mice.

Robust, automated sleep scoring by a compact neural network with distributional shift correction.

❖ Distributional shift correction

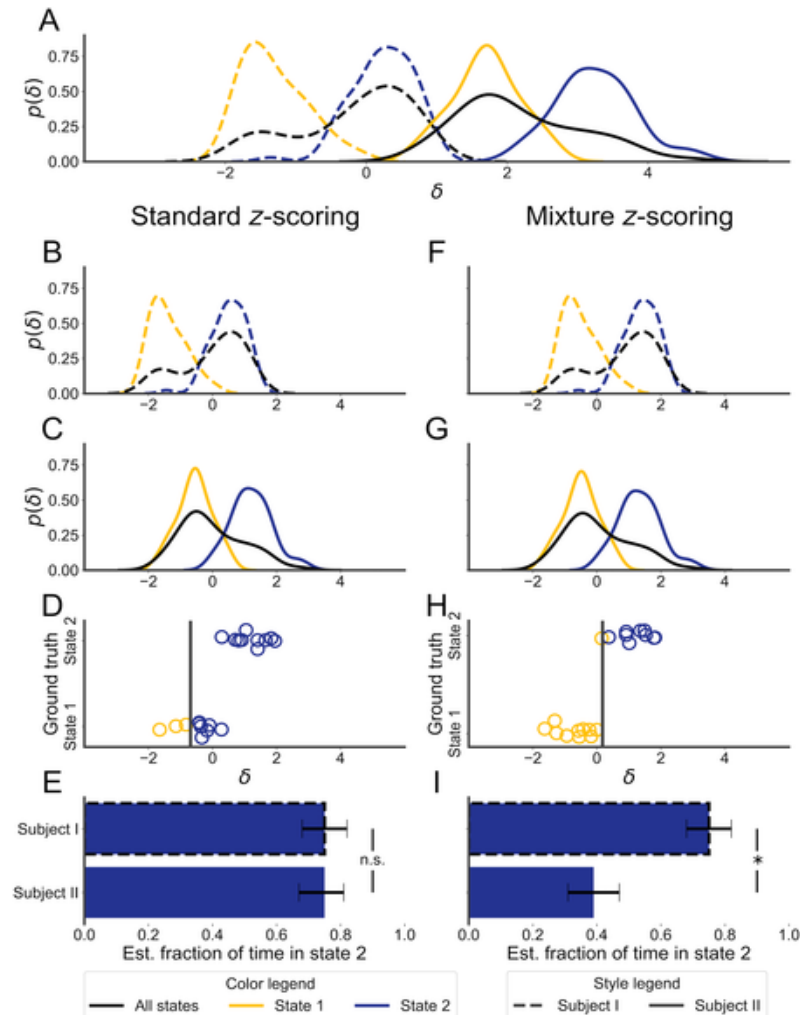


Fig 2. Correcting for distributional shift prevents a false negative in a simple model.

Robust, automated sleep scoring by a compact neural network with distributional shift correction.

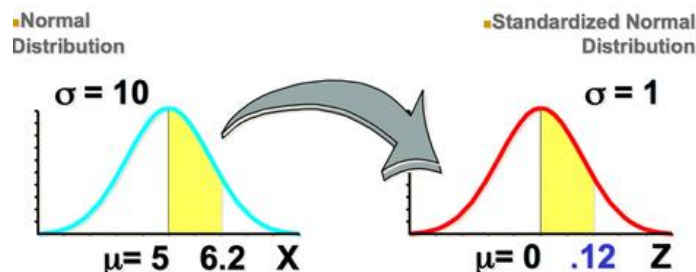
❖ Distributional shift correction

z-scores

$$Z = \frac{\Phi - \mu}{\sigma}$$

Example

$$Z = \frac{X - \mu}{\sigma} = \frac{6.2 - 5}{10} = .12$$



Mixture z-scoring

$$Z_M = \frac{\Phi - w^\top \hat{\mu}}{\sqrt{w^\top (\hat{\sigma}^2 + (\hat{\mu} - w^\top \hat{\mu})^2)}}$$

$$\phi_Z = \frac{\phi - \mu_G}{\sigma_G} = \frac{\phi - w^\top \mu}{\sqrt{w^\top (\sigma^2 + s)}} \quad \mu_G := \mathbb{E}[\phi] = w^\top \mu$$

$$w_i := P(Y = i) \quad \sigma_G^2 := \mathbb{V}[\phi] = w^\top (\sigma^2 + s)$$

$$\mathbb{E}[\phi | Y = i] := \mu_i \quad \mathbb{V}[\phi] = w^\top \sigma^2 + w^\top (\mu - w^\top \mu)^2$$

$$\sigma_i^2 := \mathbb{V}[\phi | Y = i] \quad s := (\mu - w^\top \mu)^2$$

σ_G^2 comes from the law of total variance:

$$\mathbb{V}[\phi] = \mathbb{E}[\mathbb{V}[\phi | Y]] + \mathbb{V}[\mathbb{E}[\phi | Y]]$$

Robust, automated sleep scoring by a compact neural network with distributional shift correction.

❖ Distributional shift correction

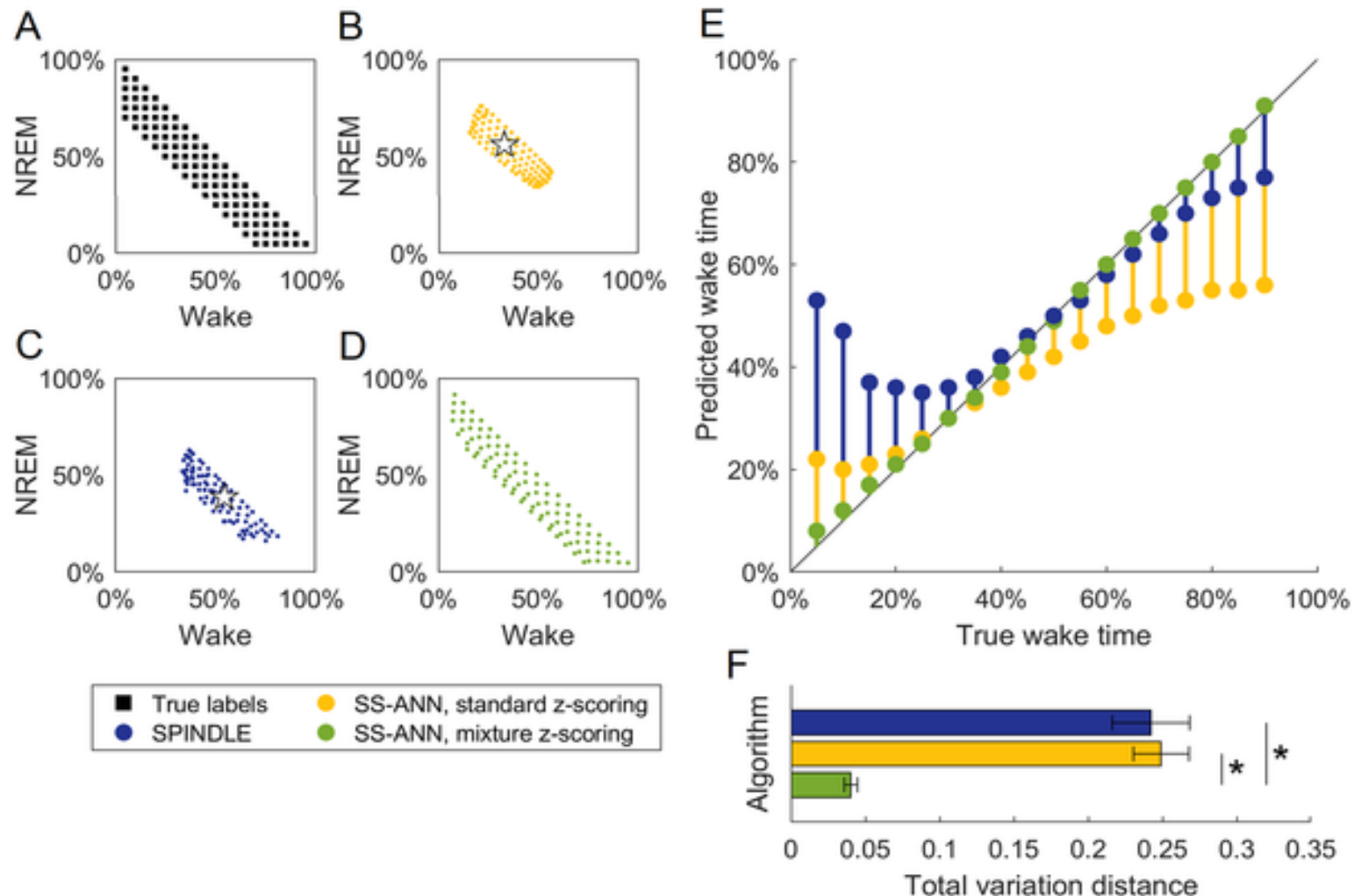


Fig 3. Comparison of sleep scoring algorithms on recordings with programmatically varied class balances.

SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.

❖ Automated sleep scoring by neural network

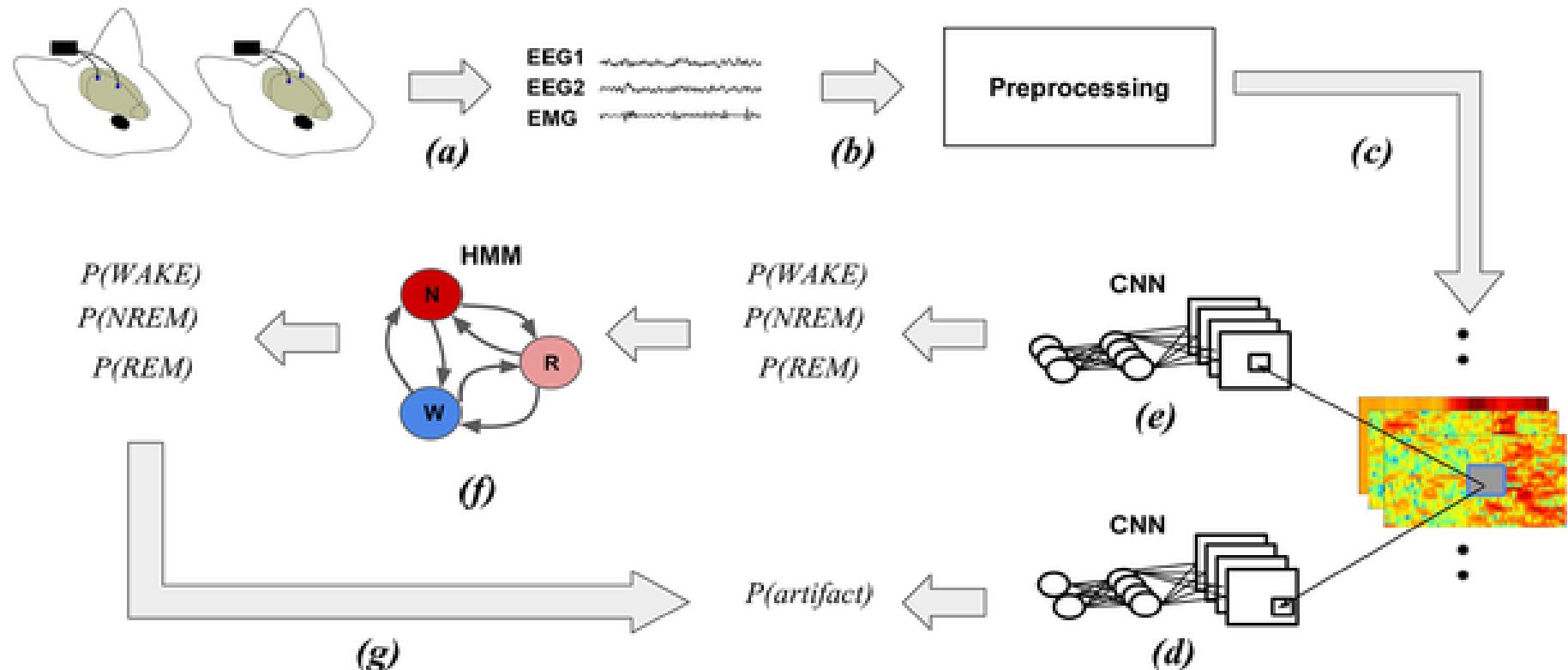


Fig 4. Conceptual overview of the SPINDLE framework.

SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.

❖ Automated sleep scoring by neural network

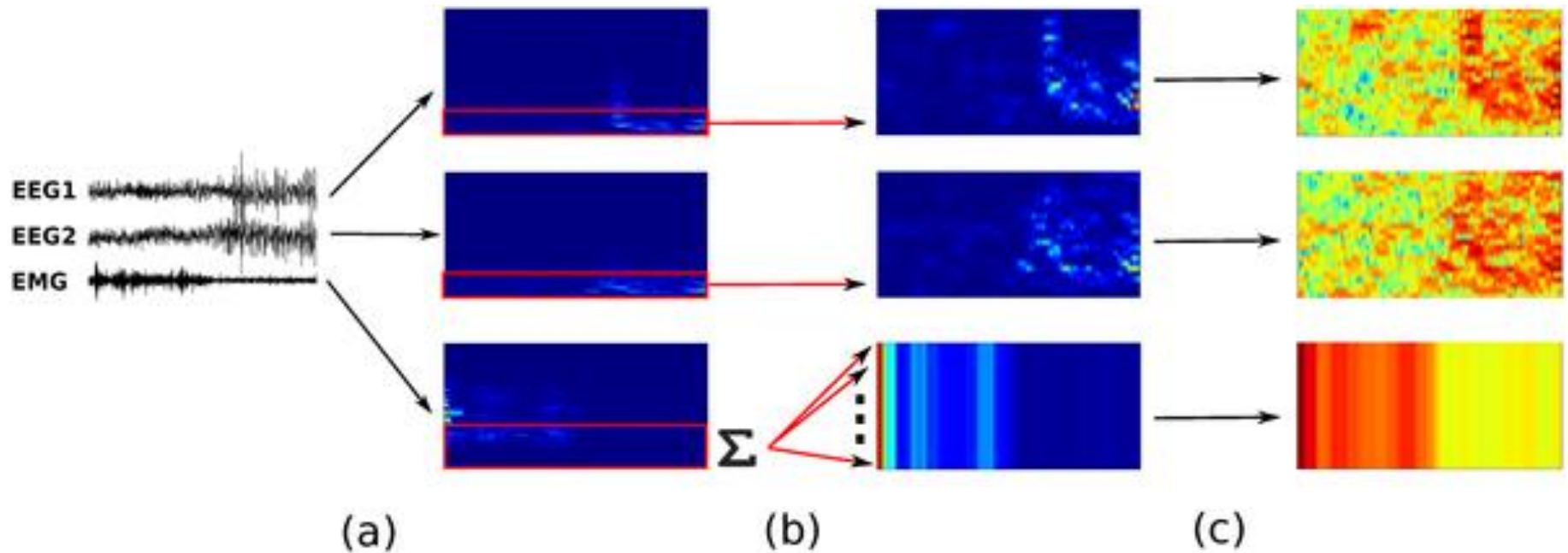


Fig 5. Data preprocessing and CNN input preparation.

SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.

❖ Automated sleep scoring by neural network

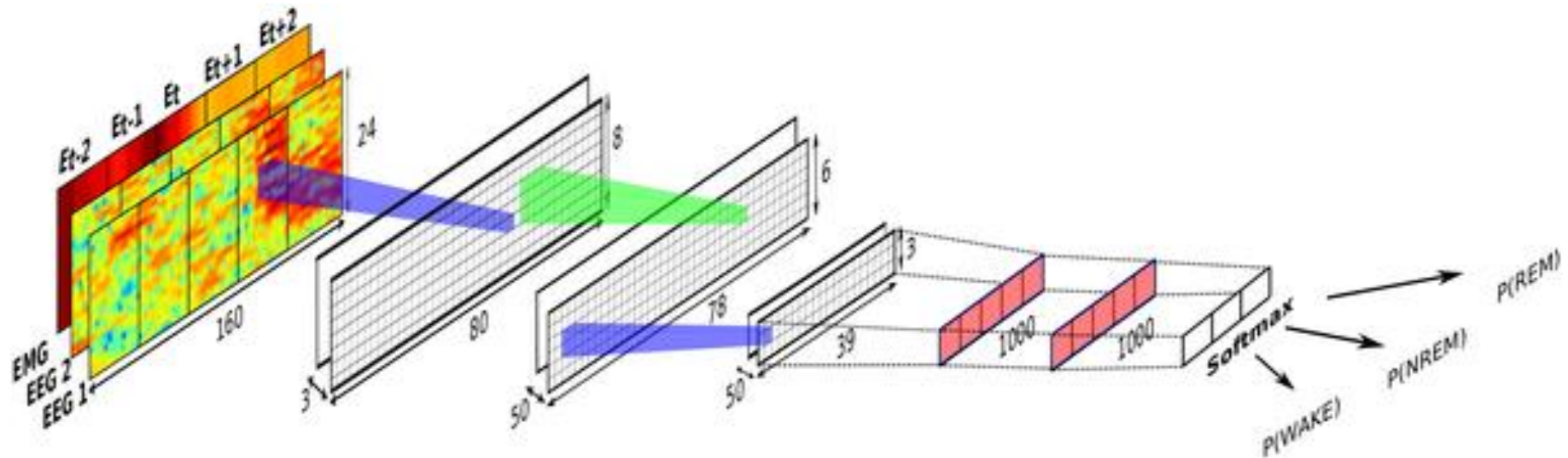


Fig 6. Sleep scoring CNN architecture.

SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.

❖ Automated sleep scoring by neural network

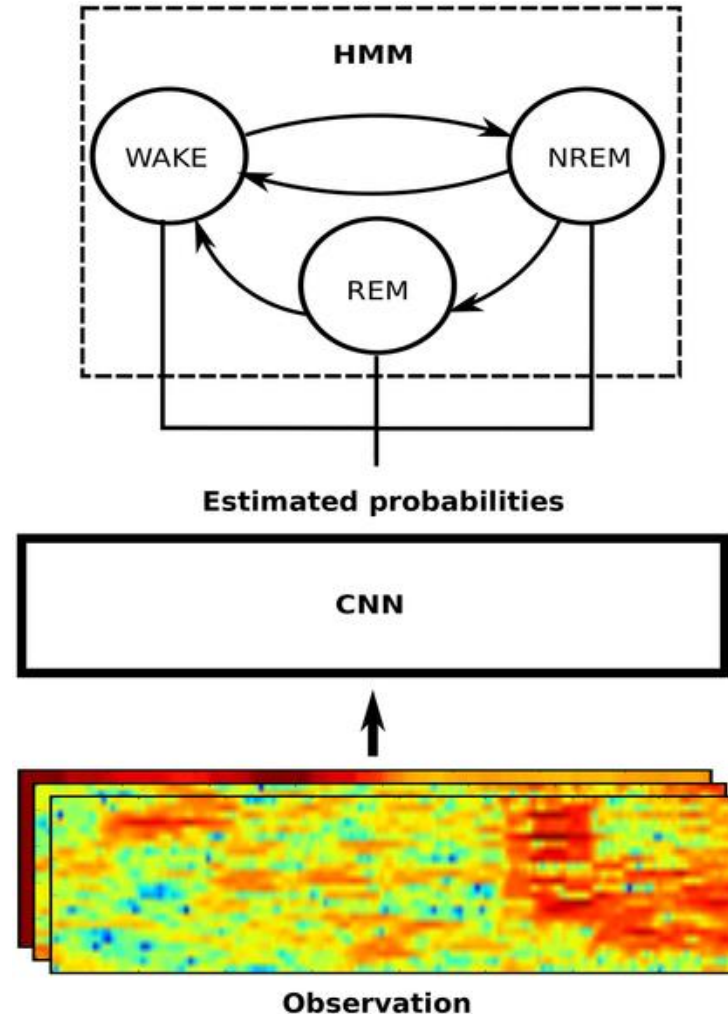


Fig 7. CNN-HMM for constraining state transitions.

Robust, automated sleep scoring by a compact neural network with distributional shift correction.

❖ Automated sleep scoring by neural network

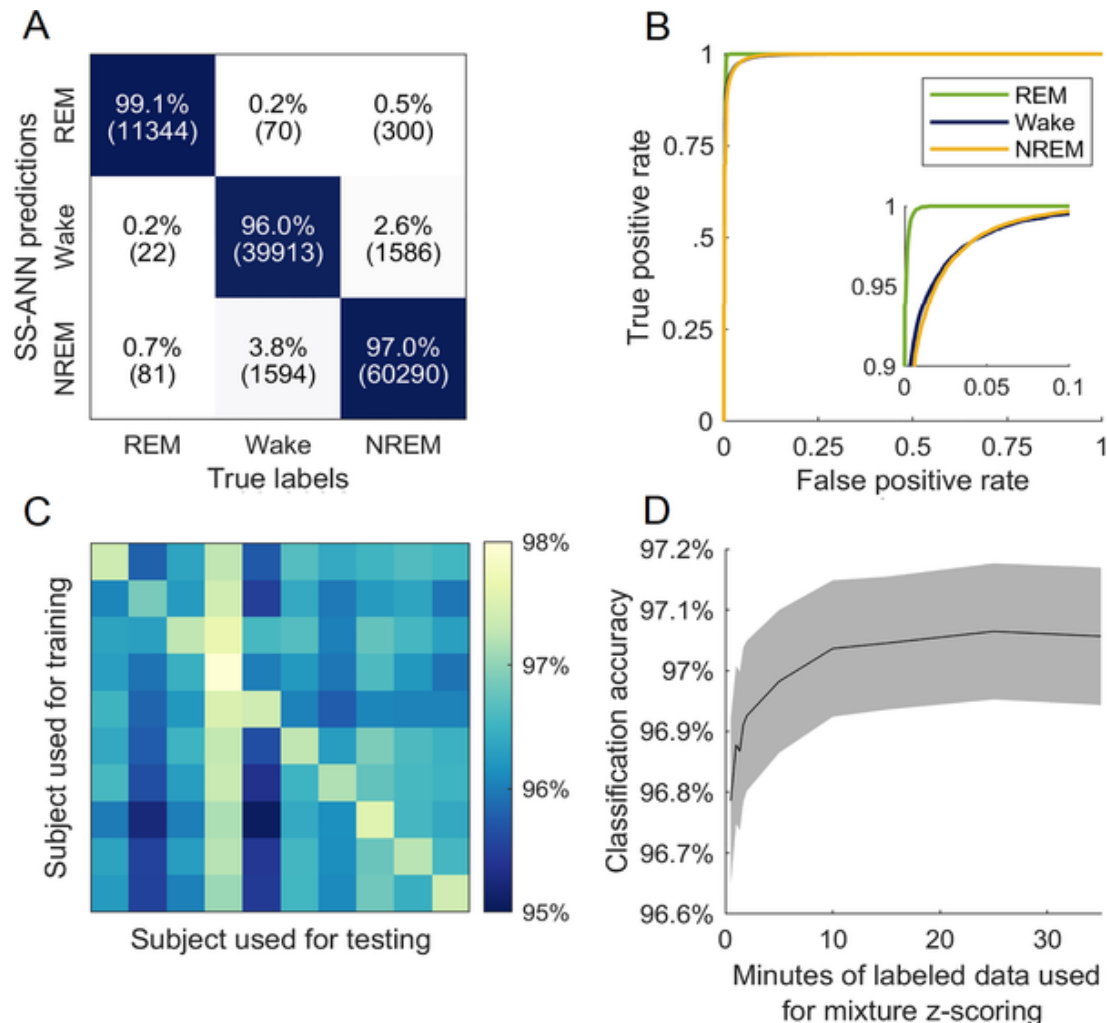


Fig 8. Validation of SS-ANN.

Robust, automated sleep scoring by a compact neural network with distributional shift correction.

❖ AccuSleep interface for sleep scoring

User manual

Parameters for all recordings from one subject

Sampling rate (Hz): 512 ✓ Epoch length (sec): 2.5 ✓

Recording list

add remove

Recording 1
Recording 2
Recording 3
Recording 4

Data / actions for the selected recording from this subject

Select EEG file D:\Data\Subject1\Day4\EEG.mat ✓

Select EMG file D:\Data\Subject1\Day4\EMG.mat ✓

Set / load label file D:\Data\Subject1\Day4\labels.mat ✓

Score selected manually ✓ ✓ ✓ ✓ ✓ Create calibration data file ✓ ✓ ✓ ✓ ?

Data / actions for all recordings from this subject

Load calibration data file D:\Data\Subject1\Day1\calibrationData.mat ✓

Load trained network file D:\Data\trained_network.mat ✓

Score all automatically ✓ ✓ ✓ ✓ ✓ ✓ ✓

☐ Only overwrite undefined epochs

Minimum bout length (sec): 5

Messages

EMG file selected
Label file found
Inspecting EEG file...
EEG file selected
Inspecting EMG file...
EMG file selected
Label file found

AccuSleep

Fig 9. AccuSleep interface for automated sleep scoring.

Robust, automated sleep scoring by a compact neural network with distributional shift correction.

❖ AccuSleep interface for sleep scoring

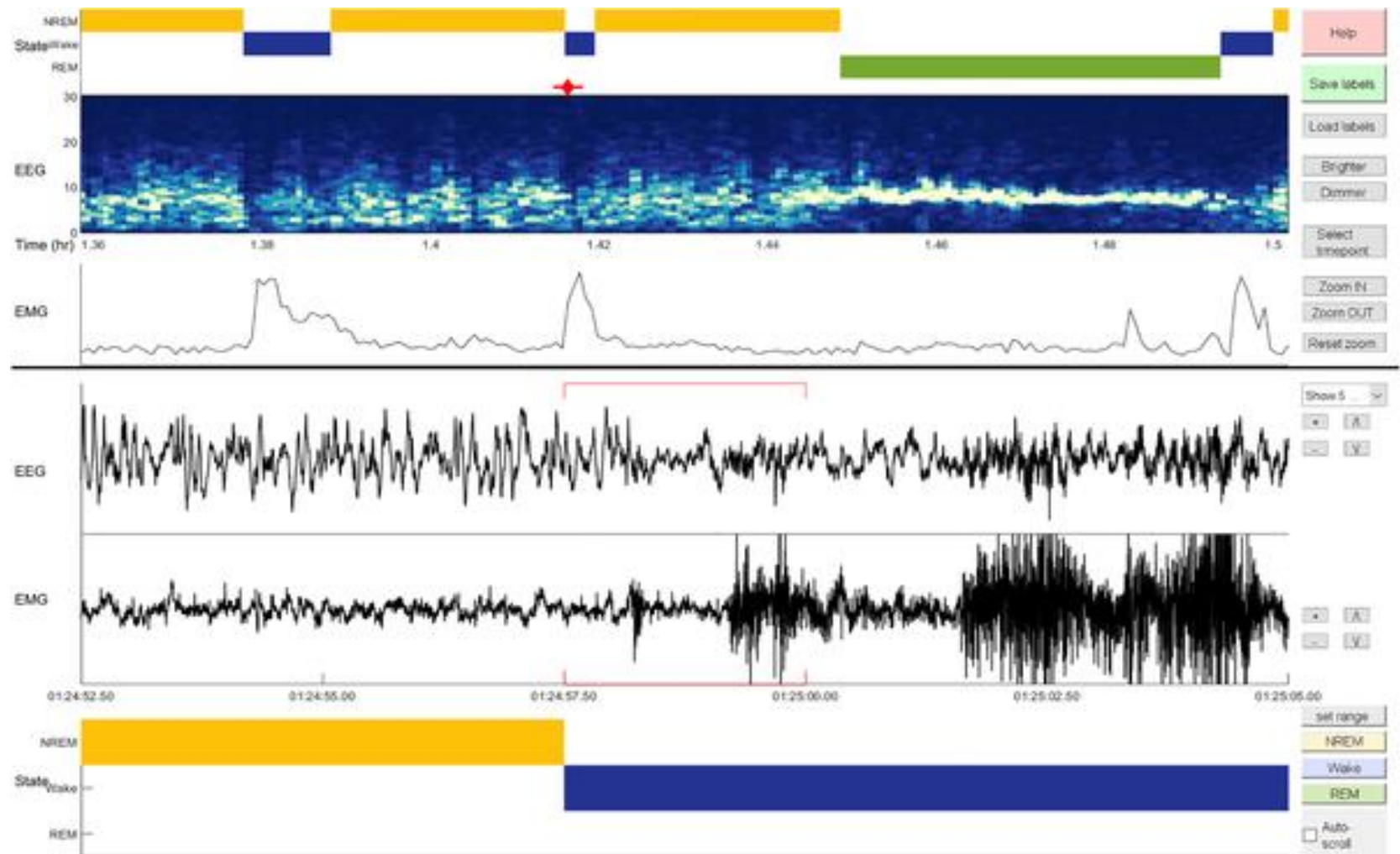


Fig 10. AccuSleep interface for manual sleep scoring.

❖ Our results

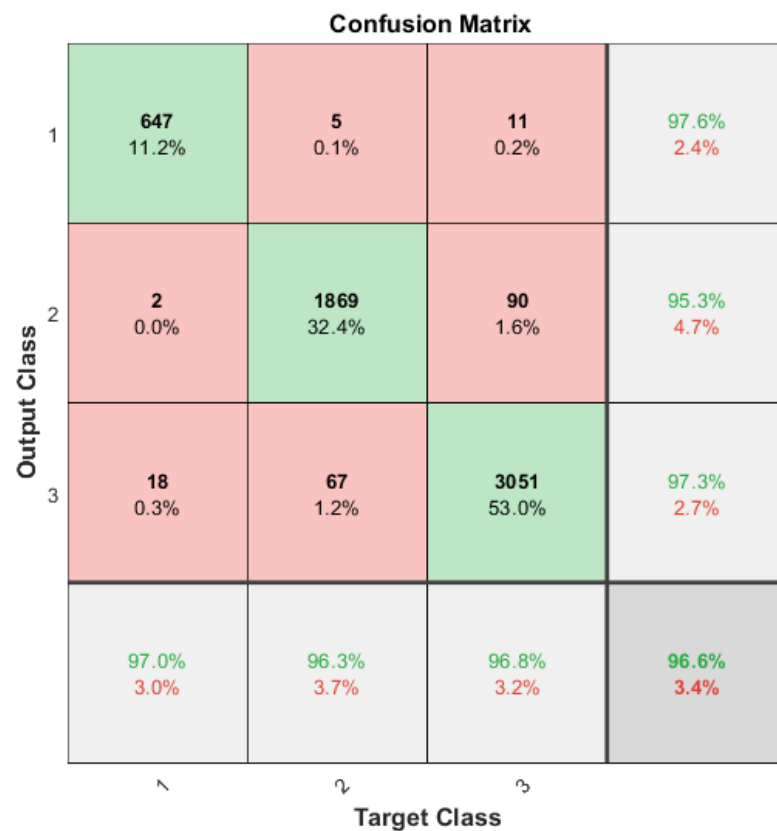
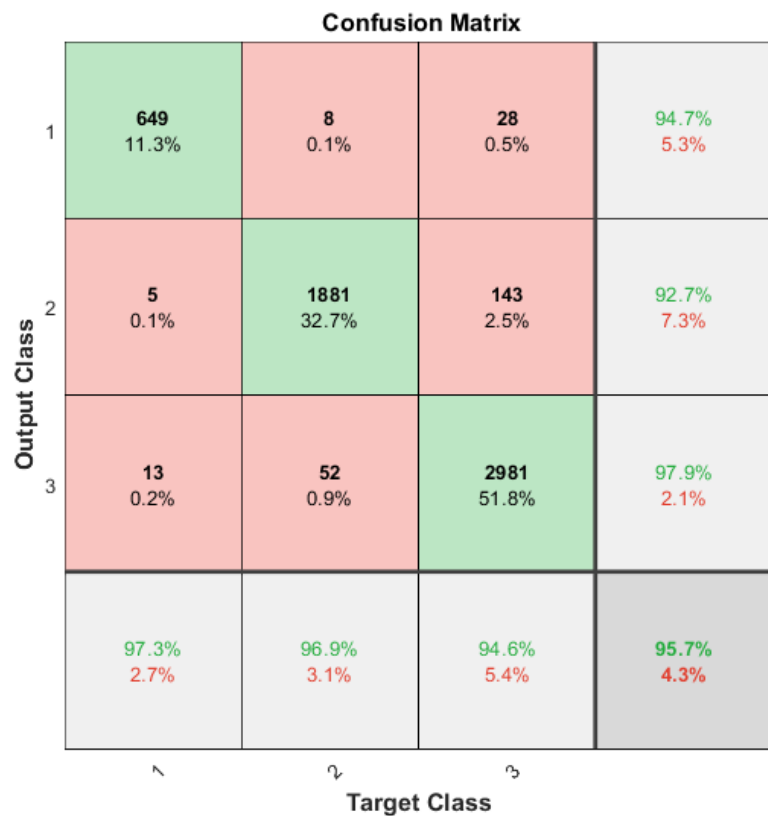
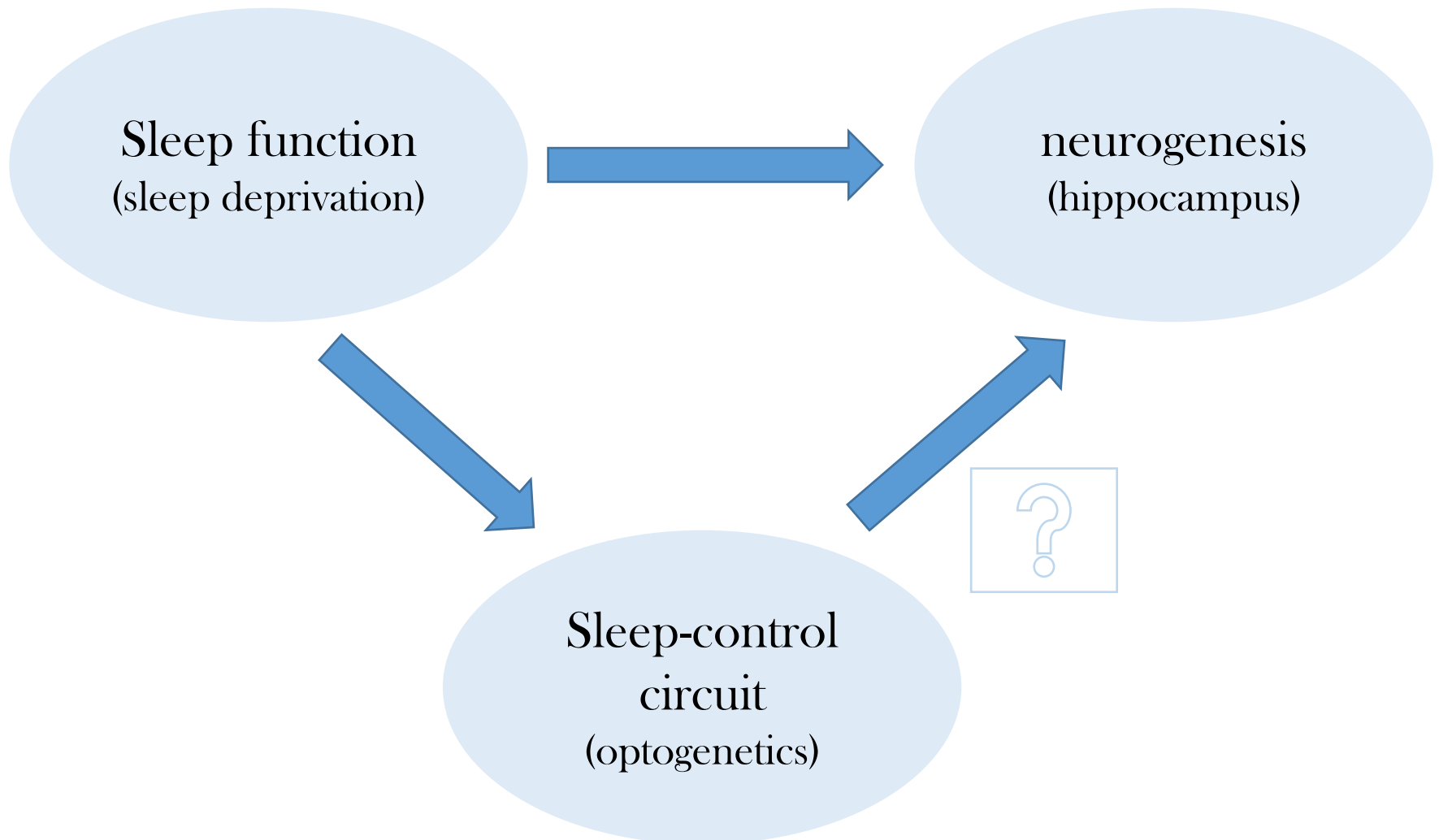


Fig 11. confusion matrix of auto-mated sleep scoring at different parameters.

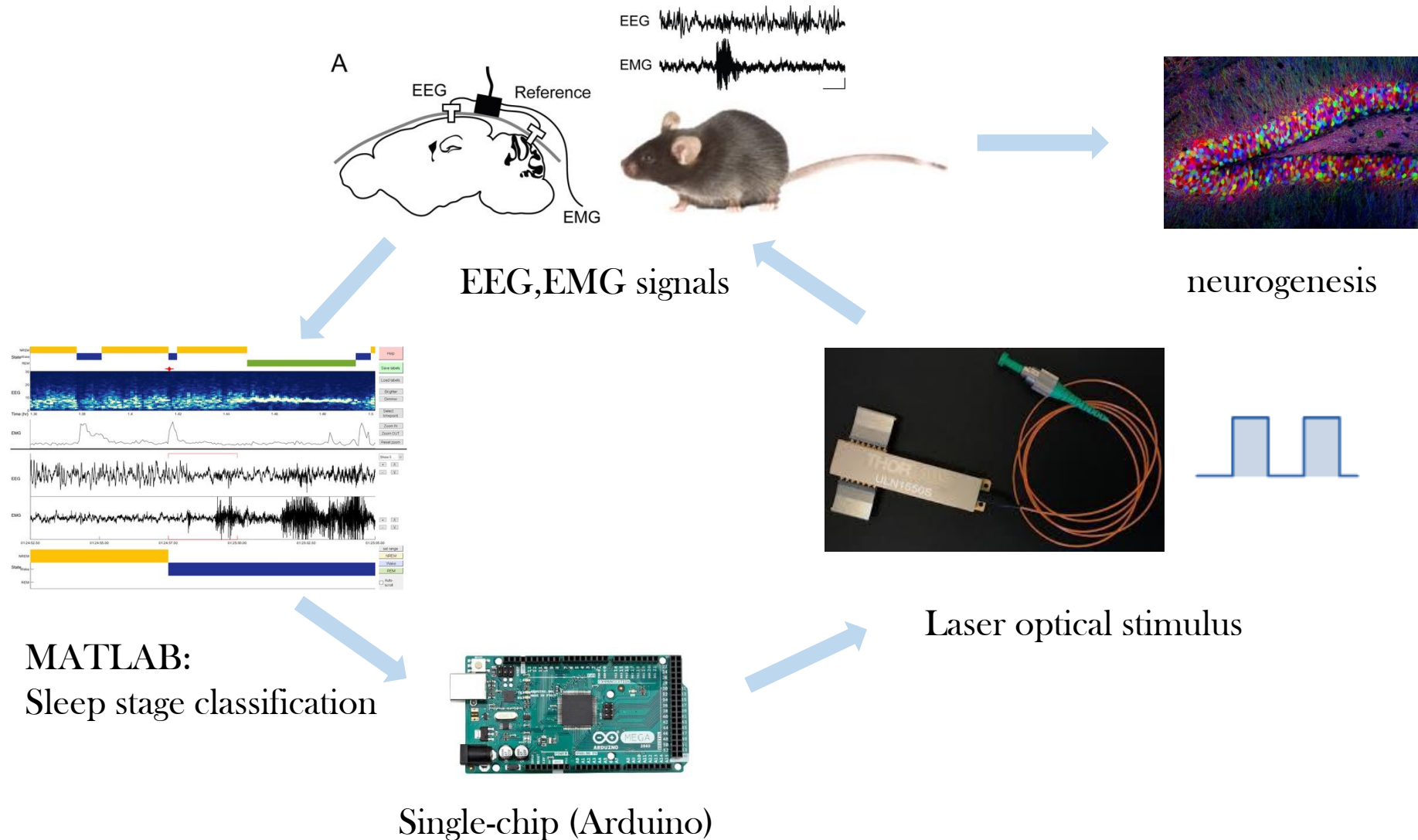
Project Plan

❖ Project purpose



Project Plan

❖ Project design: close-loop



References

Barger Z, Frye CG, Liu D, Dan Y, Bouchard KE (2019) **Robust, automated sleep scoring by a compact neural network with distributional shift correction.** PLOS ONE 14(12): e0224642. <https://doi.org/10.1371/journal.pone.0224642>
<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0224642>

Miladinović Đ, Muheim C, Bauer S, Spinnler A, Noain D, et al. (2019) **SPINDLE: End-to-end learning from EEG/EMG to extrapolate animal sleep scoring across experimental settings, labs and species.** PLOS Computational Biology 15(4): e1006968.
<https://doi.org/10.1371/journal.pcbi.1006968>
<https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1006968>