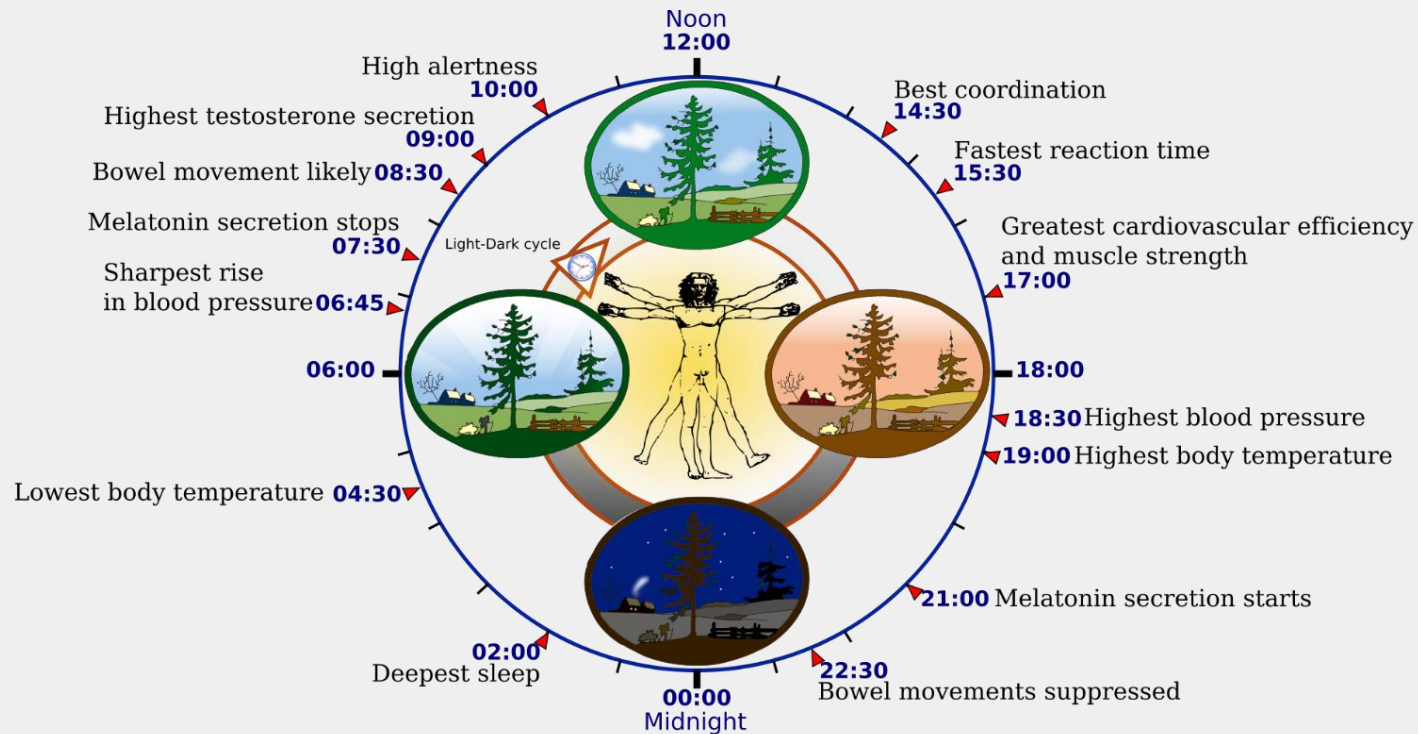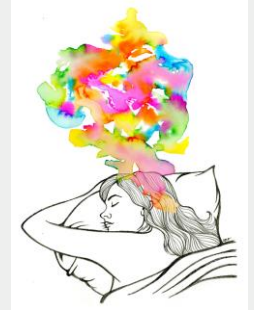JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

LightSleepNet: A Lightweight Deep Model for Rapid Sleep Stage Classification with Spectrograms
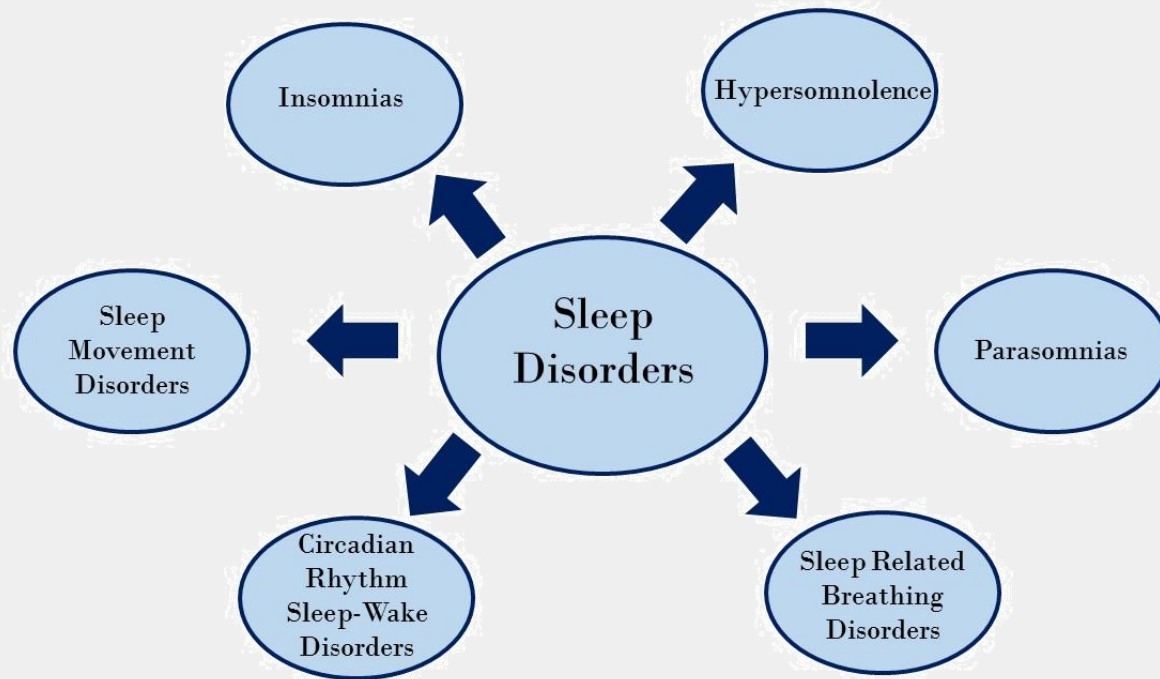
Authors:

Dongdong Zhou, Qi Xu, Jian Wang, Jiacheng Zhang, Guoqiang Hu, Lauri Kettunen, Zheng Chang, Fengyu Cong
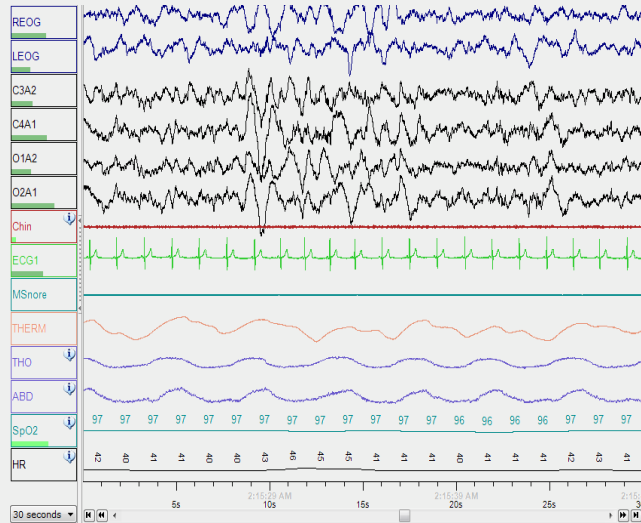
The human biological clock

Sleep disorders

Hypnogram labelled by clinician

Polysomnography (PSG) recordings

Visual inspection

Time-consuming,
Subjective error

W: wake; REM: Rapid Eye
Movement; N1-N3 (Non-REM)

Shortcomings

- Time-consuming
- Subjective error
- Well trained (demanding)

Experimental databases

- Sleep Heart Health Study (SHHS): 100 subjects, EEG C4

- Sleep-EDF Database Expanded (Sleep-EDF, 2018): 78 subjects, EEG Fpz-Cz

- Sleep-EDF Database (Sleep-EDF, 2013): 20 subjects, EEG Fpz-Cz

Dataset	W	N1	N2	N3	REM	Total
SHHS-100	23708	3010	41207	14306	14989	97220
Sleep-EDF	69518	21522	69132	13039	25835	199046
Sleep-EDF-V1	10917	2804	17799	5703	7717	44220

LightSleepNet
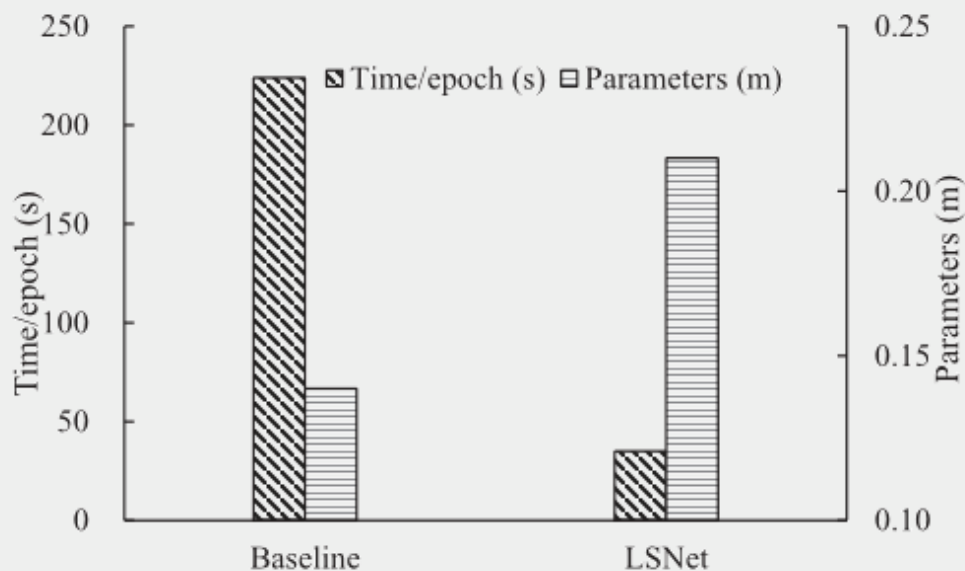

(a) Proposed model

(b) M-Apooling2D

(c) MC Block
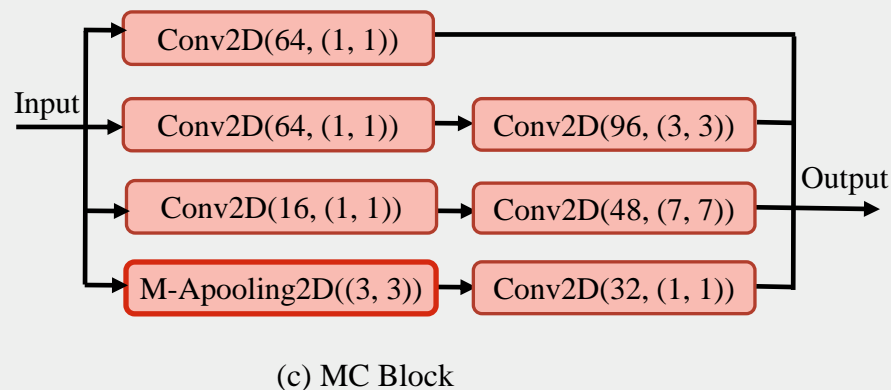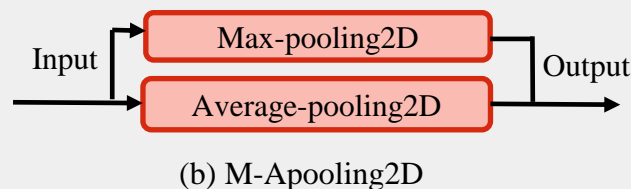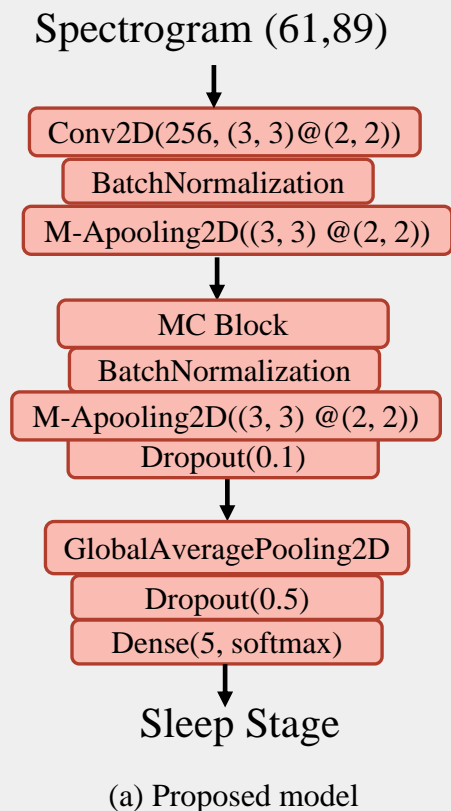
Baseline:

- Same model structure
- The filter size of N×N is replaced by the filer size of N
- Time series as the input

Experimental results

- Model parameters and computational cost

Baseline: 0.14 million parameters; 224 seconds for one epoch training

LSNet: 0.21 million parameters; 35 seconds for one epoch training

Experimental results

- Performance comparison

Accuracy (*ACC*), Cohen's kappa coefficient (*K*)

Study	Dataset	Method	Input channel	Input type	Parameters ($\times 10^6$)	Subjects	*ACC*(%)	*K*(%)
Proposed (epoch-wise)	SHHS-100	Deep CNN	C4-A1	Spectrogram	0.2	100	86.7	81.3
Proposed (subject-wise)	SHHS-100	Deep CNN	C4-A1	Spectrogram	0.2	100	85.6	79.4
Sors et al. [11]	SHHS	Deep CNN	C4-A1	Time series	2.2	5728	**87**	81
Seo et al. [16]	SHHS	CNN + LSTM	C4-A1	Time series	-	5791	86.7	79.8
Zhang et al. [12]	SHHS	CNN + LSTM	2EEG + 2EOG + EMG	Spectrogram	1.3	5793	**87**	**82**
Proposed (epoch-wise)	Sleep-EDF	Deep CNN	Fpz-Cz	Spectrogram	0.2	78	**83.7**	**77.5**
Proposed (subject-wise)	Sleep-EDF	Deep CNN	Fpz-Cz	Spectrogram	0.2	78	83.4	76.7
Supratak et al. [13]	Sleep-EDF	CNN + LSTM	Fpz-Cz	Time series	1.3	78	83.1	77
Mousavi et al. [15]	Sleep-EDF	CNN + LSTM	Fpz-Cz	Time series	21	78	80.0	73
Proposed (epoch-wise)	Sleep-EDF-v1	Deep CNN	Fpz-Cz	Spectrogram	0.2	20	**88.3**	**84.5**
Proposed (subject-wise)	Sleep-EDF-v1	Deep CNN	Fpz-Cz	Spectrogram	0.2	20	86.1	81.0
Supratak et al. [14]	Sleep-EDF-v1	CNN + LSTM	Fpz-Cz	Time series	21	20	82.0	76
Supratak et al. [13]	Sleep-EDF-v1	CNN + LSTM	Fpz-Cz	Time series	1.3	20	85.4	80
Mousavi et al. [15]	Sleep-EDF-v1	CNN + LSTM	Fpz-Cz	Time series	2.6	20	84.3	79

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