Predicting co-existence of sources through self-supervised Contrastive Predicting Coding to reveal underlying structures during sleep

I. Huijben[1], L. Hermans[1], M. van Gilst[1,2], R. van Sloun[1], S. Overeem[1,2]

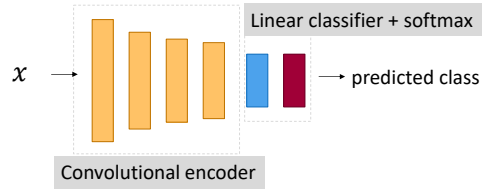
[1]Eindhoven University of Technology, Eindhoven, the Netherlands.
[2]Center for Sleep Medicine, Kempenhaeghe, Heeze, The Netherlands.

PROBLEM DEFINITION

- ✓ **Clinical challenge:** reveal co-existence of different sleep stages during the night, rather than predicting the most prevalent stage.
- ✓ **Current approach:** Softmax output of a supervised sleep stage classifier reveals continuous transitions of these stages [1].
- ✓ **Hypothesis:** Supervised models can be overconfident, resulting in skewed softmax outputs towards one class/sleep stage.
- ✓ **Goal:** Develop a model that is less influenced by the discrete labels.
- ✓ **Method:** Train in an unsupervised fashion (using CPC [2]), followed by a supervised classifier on the frozen latent space.

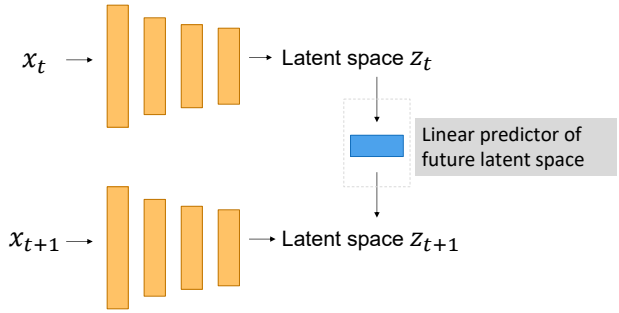
MODELS

Benchmark: Convolutional supervised classifier

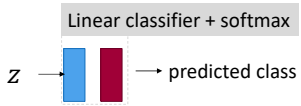


Unsupervised contrastive predictive coding [2]

Phase 1:

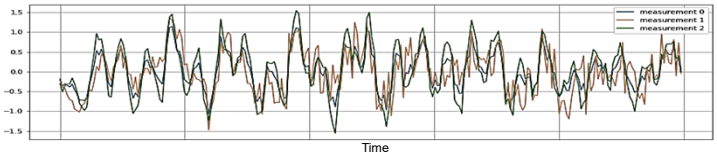


Phase 2:

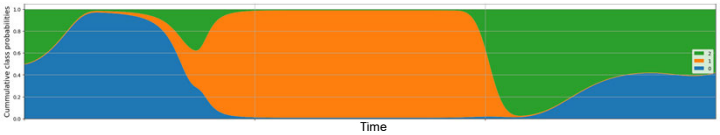


SYNTHETIC DATA

Ground-truth of co-existence of sleep stages is unknown, so we started with synthetic data. Each measurement is a combination of 3 sinusoidal sources:



The ground-truth presence of each of the sources is known now:



RESULTS

Softmax outputs **supervised classifier**

Softmax outputs classifier on **CPC** latent space

The average Kullback-Leibler divergence between the ground truths of the test set
and predictions was 11.2 vs 0.04 for the supervised vs semi-supervised (CPC) model.

FUTURE WORK

Validate that similar differences are visible for real PSG data, recorded during sleep.

REFERENCES

[1] Stephansen *et al.* (2018). Neural network analysis of sleep stages enables efficient diagnosis of narcolepsy.
[2] Oord *et al.* (2018). Representation learning with contrastive predictive coding.