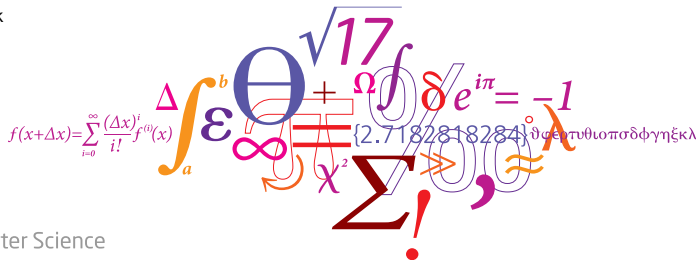


# Deep Convolutional and Recurrent Neural Networks for Interpretable Analysis of EEG Sleep Stage Scoring

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Github: [anderslaunerbaek/Deep\\_Learning\\_Project](https://github.com/anderslaunerbaek/Deep_Learning_Project)

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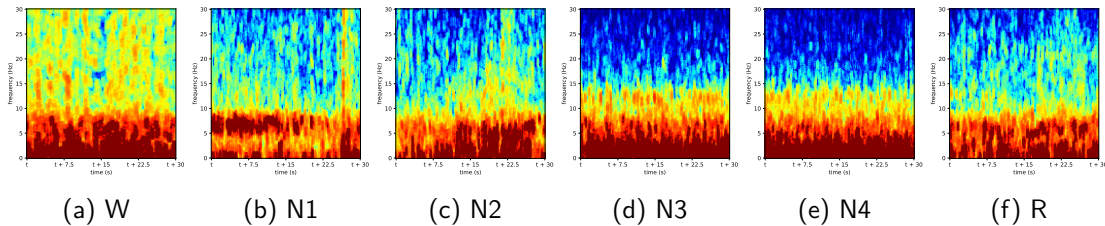


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# Data

## Sleeping Stages



Sleep Stage	W	N1	N2	N3	N4	R
Dist. (in %)	12	7	46	9	6	20

Table: The distribution of the labels for all 20 subjects.

- Article by Albert Vilamala, Kristoffer H. Madsen and Lars K. Hansen (2017) [1]
- CNN: VGGNet 16
- RNN: VGGNet 16 + LSTM cell

		Predicted						Normalized pred. (in %)					
		W	N1	N2	N3	N4	R	W	N1	N2	N3	N4	R
CNN	W	495	145	29	11	1	20	71	21	4	2	0	3
	N1	25	211	43	0	0	62	7	62	13	0	0	18
	N2	4	51	1313	104	17	68	0	3	84	7	1	4
	N3	0	2	11	164	64	0	0	1	5	68	27	0
	N4	0	0	0	54	91	0	0	0	0	37	63	0
	R	17	80	46	0	0	591	2	11	6	0	0	81
RNN	W	578	39	26	7	1	43	83	6	4	1	0	6
	N1	38	107	64	0	0	132	11	31	19	0	0	39
	N2	8	13	1314	102	28	92	1	1	84	7	2	6
	N3	3	0	18	125	95	0	1	0	7	52	39	0
	N4	0	0	1	60	84	0	0	0	1	41	58	0
	R	19	36	43	0	0	636	3	5	6	0	0	87

Study	Precision	Sensitivity	F <sub>1</sub> -score	Accuracy
CNN	65- <b>68</b> -70	71- <b>71</b> -72	67- <b>69</b> -70	92- <b>92</b> -92
RNN	62- <b>65</b> -67	63- <b>66</b> -69	62- <b>64</b> -67	92- <b>92</b> -92

Table: **Mean** and corresponding 95% confident values computed by 100.000 bootstrap iterations with replacement.

# Performance Sensitivity Maps

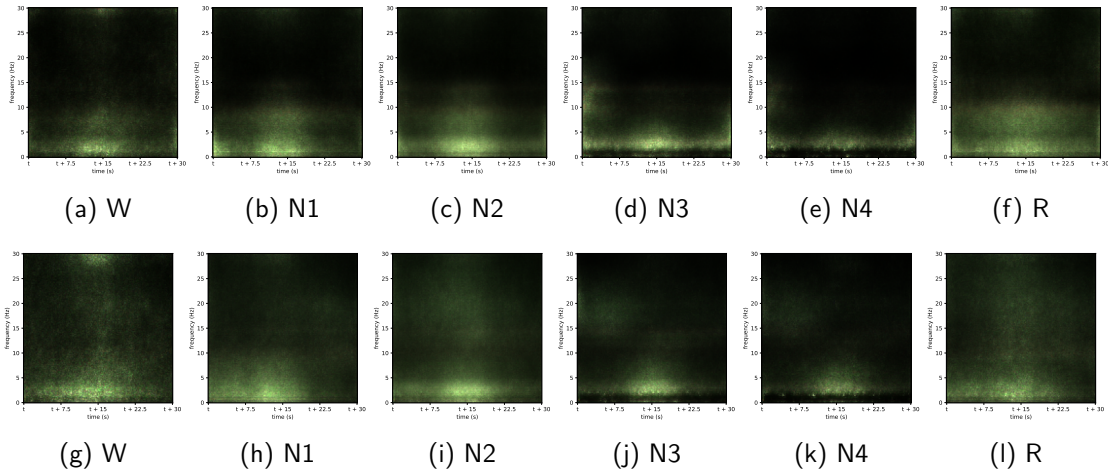



Figure: First row is the CNN. Second row is the RNN.

- Successfully reproduced [1] in TF which was one of the objectives, despite using few different approaches.
- Added a LSTM cell to the of the VGGNet. The of the RNN does outperform the baseline network on the average performance metrics, despite the RNN does achieve a better sensitivity in the W sleep stage and in the R sleep stage.
- Improvements in this projects can be archived by merging sleeping stage N3 and N4, then follow the newest regulations.
- Study the effect of stacking multiple LSTM cells.
- Apply the LSTM cells from layers with a lower-level feature representation and a higher spatial variance.

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-  A. Vilamala, K. H. Madsen, and L. K. Hansen,  
“Deep Convolutional Neural Networks for Interpretable Analysis of EEG Sleep Stage  
Scoring,”  
*ArXiv e-prints*, Oct. 2017.

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