

# CNN-Transformer-LSTM: Automatic Sleep Apnea detection using a single-lead ECG signal

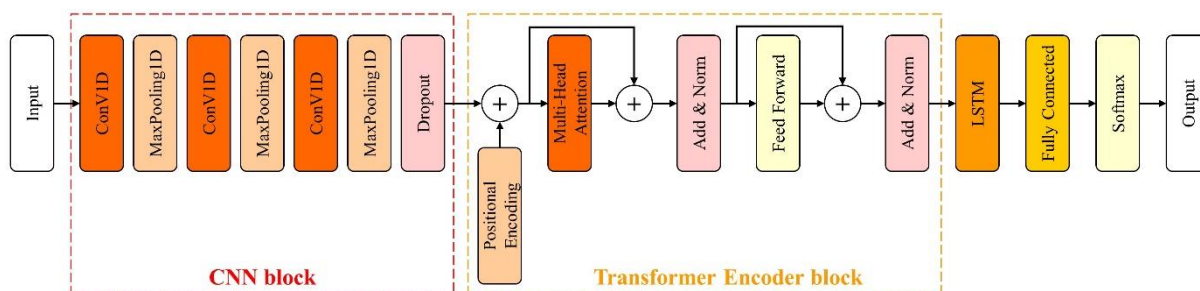
Duc Thien Pham<sup>1</sup>

## 1 Introduction

Sleep apnea (SA) is a prevalent sleep disorder characterized by repeated pauses in breathing during sleep. The analysis of Electrocardiogram (ECG) signals holds promise for SA detection. Researchers have explored various techniques to extract relevant features from the ECG signal, such as RR intervals (time between heartbeats). In this study, we proposed a CNN-Transformer-LSTM model for SA detection using a single-lead ECG signal.

## 2 Method

We have developed the CNN-Transformer-LSTM model to detect SA using a single-lead ECG signal. The PhysioNet Apnea-ECG dataset is used. The architecture of the proposed method is shown in Figure 1.



**Figure 1:** The architecture of the CNN-Transformer-LSTM model.

## 3 Results

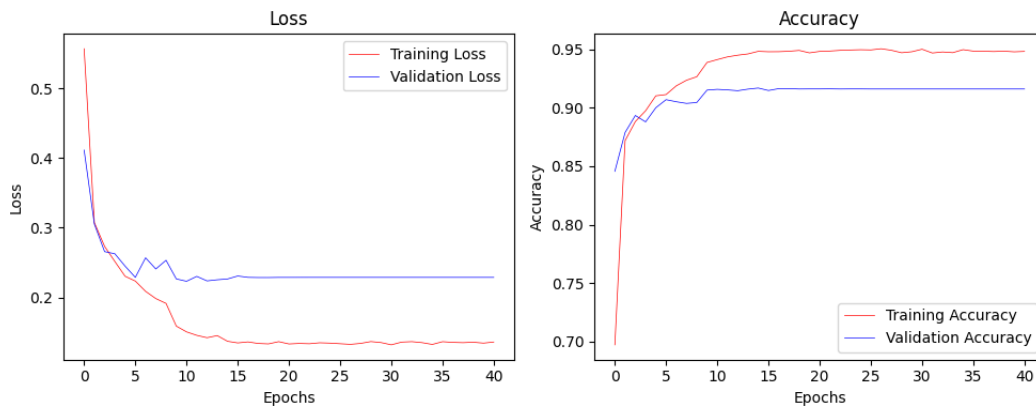
As for per-segment and per-recording performance comparison on the Physionet Apnea-ECG dataset shown in Tables 1 and 2, it can be observed that the CNN-Transformer-LSTM model achieves the best performance metric of accuracy compared to state-of-the-art studies.

References	Methods	Acc (%)	Sen (%)	Spe (%)	F1-score	AUC
(Wang et al., 2019)	LeNet-5 CNN	87.6	83.1	90.3	-	0.950
(Chang et al., 2020)	1D CNN	87.9	81.1	92.0	-	0.935
(Shen et al., 2021)	MSDA-1DCNN	89.4	89.8	89.1	-	0.964
(Qin and Liu, 2022)	1DCNN-RLM	91.1	88.9	92.4	0.883	0.970
(Tyagi et al., 2023)	FT-EDBN	89.1	83.9	92.3	0.913	0.960
(Srivastava et al., 2023)	ALexNet + LSTM	90.9	95.5	83.4	-	-
	<b>Proposed method</b>	<b>91.6</b>	<b>88.8</b>	<b>93.4</b>	<b>0.890</b>	<b>0.969</b>

<sup>1</sup> student of the doctoral degree program Applied Sciences, field of study Information Technology, e-mail: duction@kiv.zcu.cz

**Table 1:** Performance comparison with existing studies for per-segment classification.

References	Methods	Acc (%)	Sen (%)	Spe (%)	AUC	Corr
(Wang et al., 2019)	LeNet-5 CNN	97.1	100	91.7	-	0.943
(Chang et al., 2020)	1D CNN	97.1	95.7	100	-	0.865
(Shen et al., 2021)	MSDA-1DCNN	100	100	100	-	-
(Qin and Liu, 2022)	1DCNN-RLM	100	100	100	-	0.968
(Tyagi et al., 2023)	FT-EDBN	97.1	100	91.7	-	0.938
(Srivastava et al., 2023)	ALexNet + LSTM	97.1	-	-	-	-
	<b>Proposed method</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>1</b>	<b>0.982</b>

**Table 2:** Performance comparison with existing studies for per-recording classification.**Figure 2:** The accuracy and loss of Training and Validation sets.

## Acknowledgement

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## References

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