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ABSTRACT OF THE DISSERTATION
„ Implementation of deep learning methods for muscle artifact removal from EEG signals"

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The aim of this doctoral thesis is to develop a method for eliminating electromyographic artifacts from electroencephalographic (EEG) signals using deep learning techniques. The initial part of the thesis presents fundamental concepts related to electroencephalography and provides a detailed characterization of the disturbances occurring during EEG signal acquisition. A literature review enabled the identification of the main directions in the development of artifact removal methods, ranging from classical approaches such as linear regression, independent component analysis, and adaptive filtering, to modern methods involving artificial neural networks and hybrid models.

As part of the research, a proprietary hybrid neural network composed of a convolutional and a recurrent network (CNN-LSTM) was designed and tested to eliminate muscle artifacts. A generator for EEG and EMG signals was developed and validated, enabling effective preparation of training data. For the training and testing of the CNN-LSTM network, experiments were conducted involving 17 volunteers, during which both EEG and electromyographic (EMG) signals were recorded.

The developed CNN-LSTM neural network was compared with classical EEG signal denoising methods. A new signal-cleaning quality metric was introduced, based on the analysis of steady-state visually evoked potentials (SSVEP). The analysis performed on real EEG data showed that the proposed CNN-LSTM network effectively removes disturbances caused by artifacts, while preserving essential information in the EEG signal segments that are free from interference.

The conducted experiments demonstrated the superiority of the developed network over traditional EEG signal cleaning methods, both in terms of artifact removal effectiveness and fidelity of the reconstructed clean signal. The proposed hybrid CNN-LSTM network significantly improves EEG signal quality, and its short processing time enables its use in real-time applications. The results obtained in this study confirm the thesis that hybrid neural network, combined with additional EMG source recording, are effective in eliminating muscle artifacts from EEG signals.

Keywords
EEG, EMG, artifacts, deep learning, neural networks, CNN, LSTM, SSVEP

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