High-density neural interfaces and AI-based analysis of neural codes: facts and future prospects

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Introduction/Background;

High-density electromyography (HDEMG) facilitates repetitive measurements of the motor system in prevention, diagnosis, and treatment. It employs tens of closely spaced electrodes, guaranteeing robustness and accuracy. Processing techniques utilizing human-expert knowledge [1] support the separation of HDEMG into individual motor units (MUs) and the identification of neural codes governing the skeletal muscles. These expert-based techniques have started to be replaced by AI-based solutions, but their performance is poorly understood. In this study, we tested the ability of deep neural networks (DNN) to extract simple but important information about the number of active MUs from HDEMG recorded in voluntary isometric contractions.

Methods

We generated [2] 20s-long HDEMG signals (9x10 electrodes, sampling frequency of 2048 Hz) of 10 Biceps Brachii (BB) muscles at 10-90% excitation levels. Utilizing the Convolution Kernel Compensation (CKC) technique [1], HDEMG was decomposed into contributions of adjacent MUs, which significantly boosted the convergence of DNNs and decreased their sensitivity to inter- and intra-person HDEMG variability. We used ten-fold cross-validation to assess the number of active MUs in 30ms long HDEMG intervals by different DNNs.

Results;

CKC identified 32±8 groups per HDEMG, comprising 1 to 10 active MUs. In each group, DNNs accurately estimated the MU number in 50±4% of cases (estimation error of 0±1 MUs). Increasing the estimation tolerance to ±1 MU, the success rate increased to 90±5%.

Conclusion.

DNN-based estimation of the number of active MUs from HDEMG recordings of voluntary contractions is possible at relatively high time resolution but requires careful HDEMG preprocessing. We employed state-of-the-art HDEMG preprocessing techniques to achieve acceptable performance in well-specified experimental conditions. The scalability of introduced concepts to different muscles and pathologies, such as stroke, is yet to be assessed.

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Keywords

Neural interfaces, electromyography

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