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Title: Brain-Inspired Machine Learning Algorithms for Cognitive Neural Prosthetics in Realistic Environments

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Abstract: Clinical neural prosthetic systems enable paralyzed human participants to control external devices by (a) transforming brain signals recorded from implanted electrode arrays into neural features and (b) decoding neural features to predict the participant's intent. Neural decoding relies on having accurate estimates of neural activity, however, improving estimates of neural activity based on measured electrical signals has been largely unexplored. Moreover, Clinical translation of Brain Machine Interface (BMI) systems require robust, high performance decoders that can adapt to changing neural conditions and which operate efficiently enough to run on mobile, even implantable, platforms. Here we present FENet, a compact (F)eature (E)xtraction (N)etwork that learns an optimized mapping between electrical signals and neural features. We compare the performance of neural features extracted by FENet against two current gold standards: 1) the rate of neural spike events computed by counting threshold crossings of the broadband neural signal; and 2) the wavelet decomposition of the broadband neural data. We find that FENet-based features outperform these two methods, decreasing mean square error by 50 and 47 percent, respectively. For the decoding task, We present a new deep multi-state Dynamic Recurrent Neural Network (DRNN) architecture. Our DRNN is used to predict Cartesian representation of a computer cursor movement kinematics from open-loop neural data recorded from the posterior parietal cortex (PPC) of a human subject in a BMI system. we configure a small DRNN to operate with a short history of input, reducing the required buffering of input data and number of memory accesses in a neural network accelerator. Our results demonstrate that our algorithms, constrained by domain specific knowledge, can be used for novel datasets, without modification, to significantly improve performance, generalization, and efficiency of training.