CHANNEL SELECTION OF NEURAL AND ELECTROMYOGRAPHIC SIGNALS FOR DECODING OF MOTOR INTENT

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ABSTRACT

The ability to perform multiple degree of freedom (DOF) proportional control has distinct advantages when applied to next-generation prosthetic hands with individuated finger and wrist control. Regression-based methods provide simultaneously multi-DOF control and can perform untrained hand grasps (Clark et al., MEC17). Such methods use multiple feature channels per DOF but increasing channel count can diminish performance and increase the computational complexity. Ideally, one wants to use the fewest channels that provide the best performance. Here we report a comparison of channel selection methods and recommend a forward stepwise selection method with Gram-Schmidt orthogonalization applied between steps. This approach uses the fewest channels that results in equivalent or no worse performance than other methods investigated, and it is our current standard method for real-time testing.

We used data from one volunteer with transradial amputation to compare the performance of four channel selection methods: channels that correlate with movements (CORR); Gram-Schmidt orthogonalization, forward selection (GS); Least Angle Regression (LARS); and Mutual Information (MI). The subject was chronically implanted with a 32-electrode intramuscular electromyogram (EMG) array in residual forearm muscles (Ripple, LLC) and two Utah Slanted Electrode Arrays (USEAs, Blackrock Microsystems), one in each of the median and ulnar nerves. From these sources, the Mean Absolute Value of 32 single-ended and 496 differential EMG channels and neural firing rate of 192 USEA channels were calculated at 30 Hz (720 total channels). All analyses were performed offline using six online training data sets. From these data, channels were selected and a decoder was trained with subsets of single DOF movements across 6 DOFs and tested with distinct subsets. Performance was quantified by the root mean squared error (RMSE) normalized to each joint's range of motion.

All methods examined performed to similar levels in testing datasets, achieving a minimum mean RMSE of 0.11+/-0.0032 (mean+/-SEM over all DOF and datasets, no significance difference between methods). However, the number of channels necessary to achieve that best mean result differed among channel selection methods with GS requiring the fewest channels (55) and CORR requiring the most (122). MI failed to find an optimal set from 720 channels within reasonable computation time. On an Intel i7, the processing time necessary to select channels ranged from 240 milliseconds (CORR) to 52 minutes (MI, while selecting from 80 EMG channels), with GS taking 24 seconds. From these results, we recommend using the Gram-Schmidt orthogonalization, forward-selection method to choose feature channels.