# SVM-based Classification of Motor-Tasks On fMRI-BOLD Data

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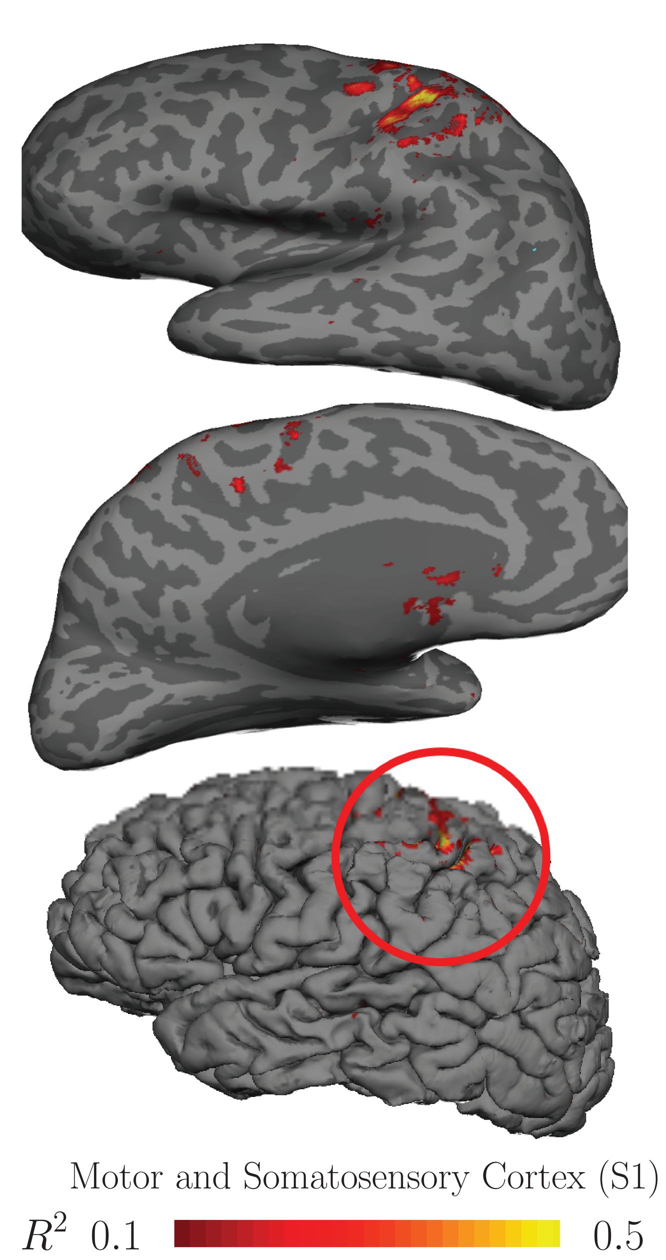
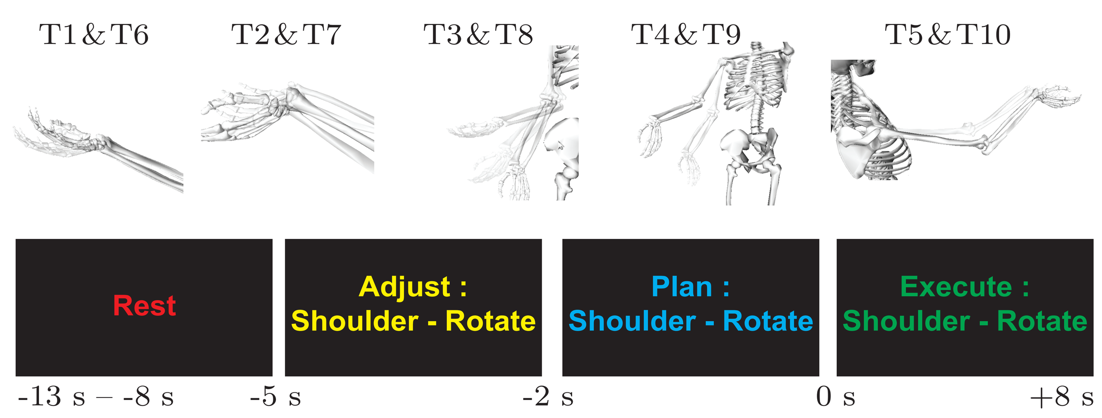
## Abstract

In this study we demonstrate the feasibility of using SVMs to classify closely related motor tasks using Functional Magnetic Resonance Imaging (fMRI) Blood Oxygenation Level Dependent (BOLD) responses. We also present novel insights into the nature of BOLD responses for limb motions. Using two classic motor paradigms—limb motions and manipulation forces—we found that motor BOLD responses for different limb motions are more discriminable than those for different manipulation force levels in reliable voxels. We also found that reliable motor voxels—ranked by cross validation score (R2) for a Haemodynamic Response Function (HRF) model—are more informative and exponentially increase classifier performance with reliability rank. Finally, we found that BOLD response's late stage temporal dynamics in motor cortex are more informative than the early stage responses.



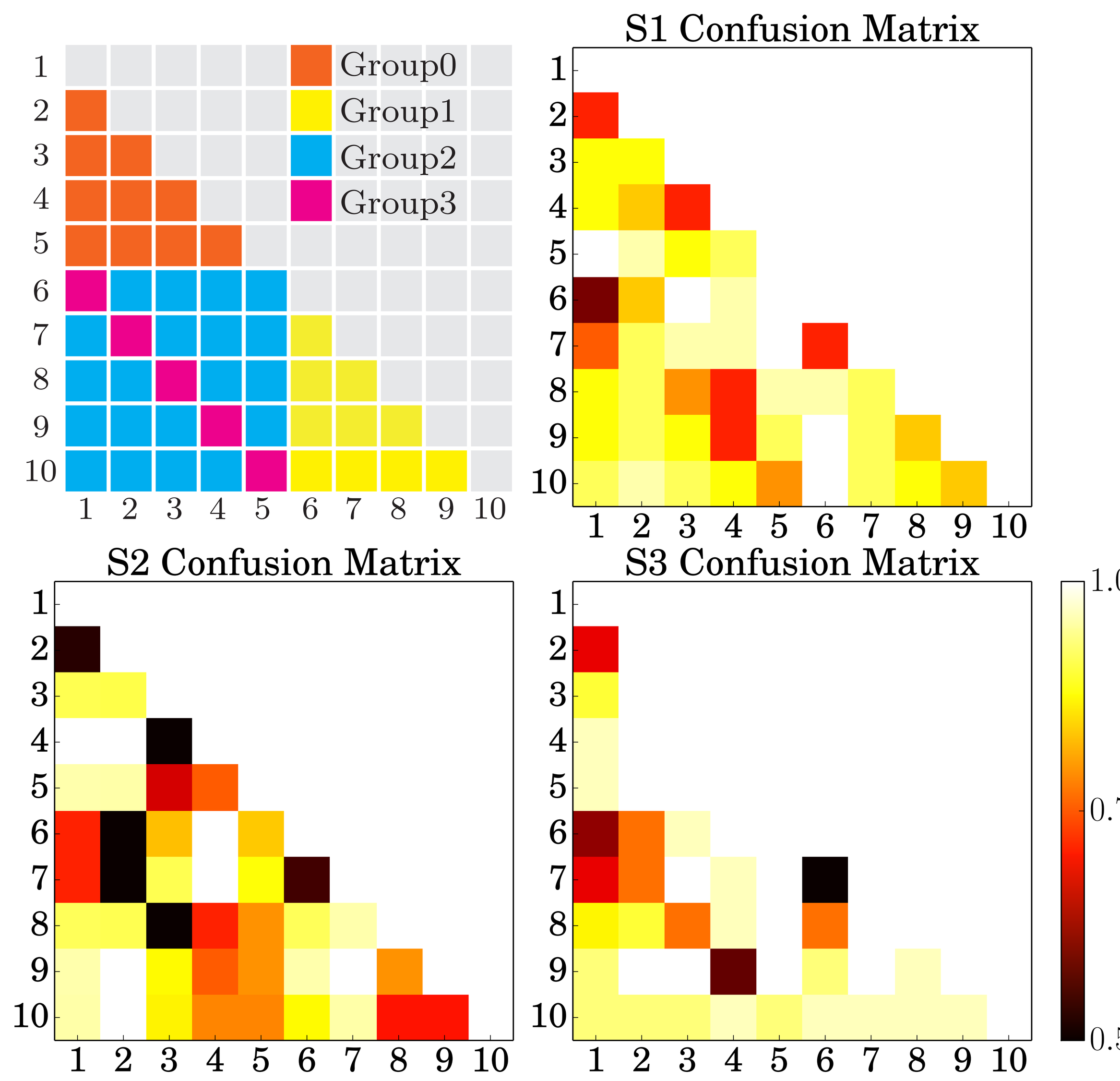

**Analyzed Brain Regions.** Our analysis used motor and somatosensory cortex voxels with reliable BOLD responses.

## Results



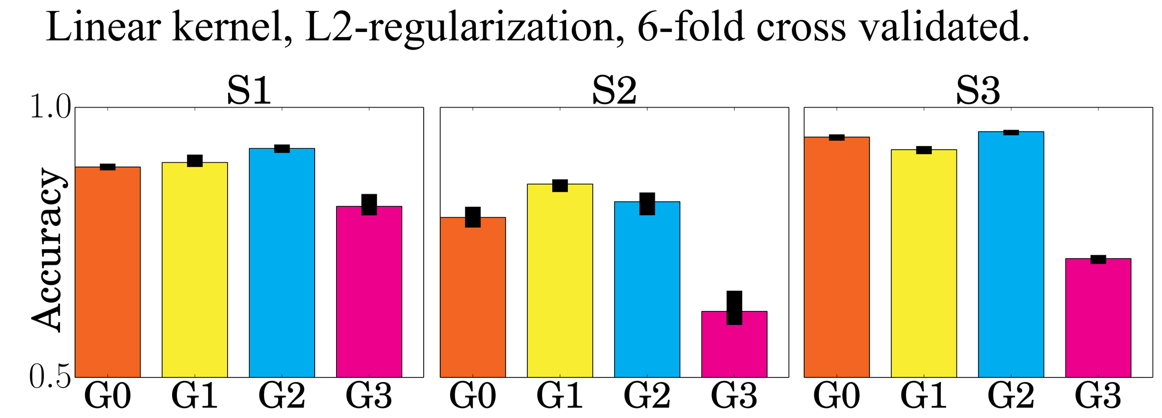

**Motor tasks.** Task T1 & T6: Wrist-Flex, T2 & T7: Wrist-Rotate, T3 & T8: Elbow-Flex, T4 & T9: Shoulder-Flex, T5 & T10: Shoulder-Rotate. T1 -- T5: Light weight, T6 -- T10: Heavy weight. Conditions replicate [1].

**Experiment stimuli.** Rest: subject relaxes (duration randomized); Adjust: subject positions arm, grasps appropriate weigh, and assumes zero-position; Plan: subject holds zero-position; Execute: subject performs motion.

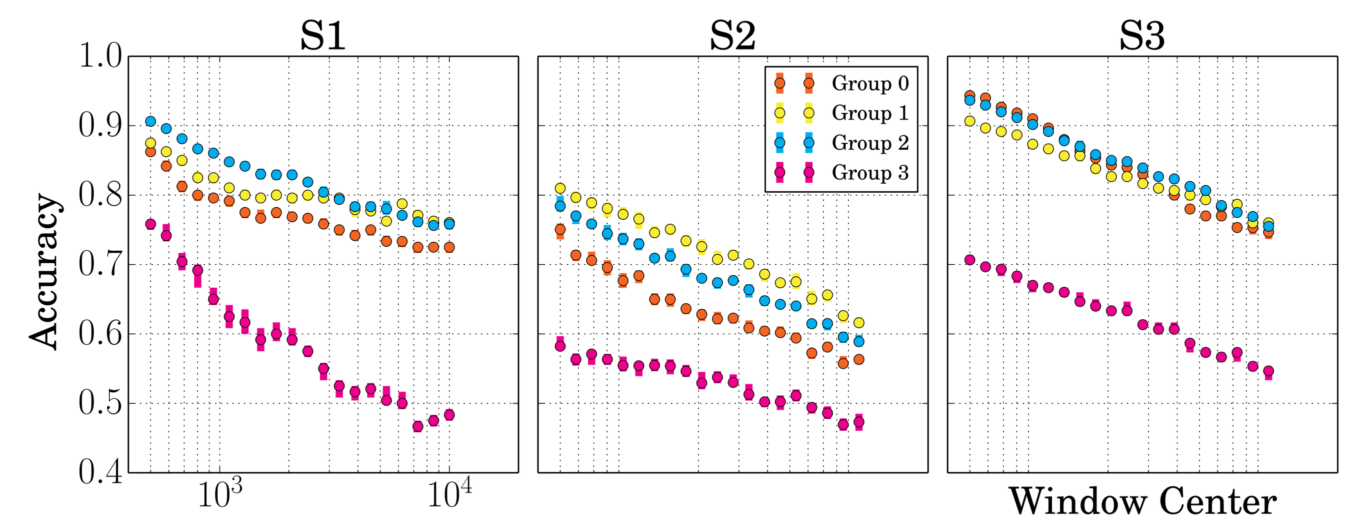



**(TL) Task Group Segmentation.** Confusion matrix of 10 binary classification tasks. Binary classifications are assigned to groups. G0: All unweighted, G1: All weighted, G3: Weighted vs. unweighted with similar motion, G2: Cross-motion and weight condition.

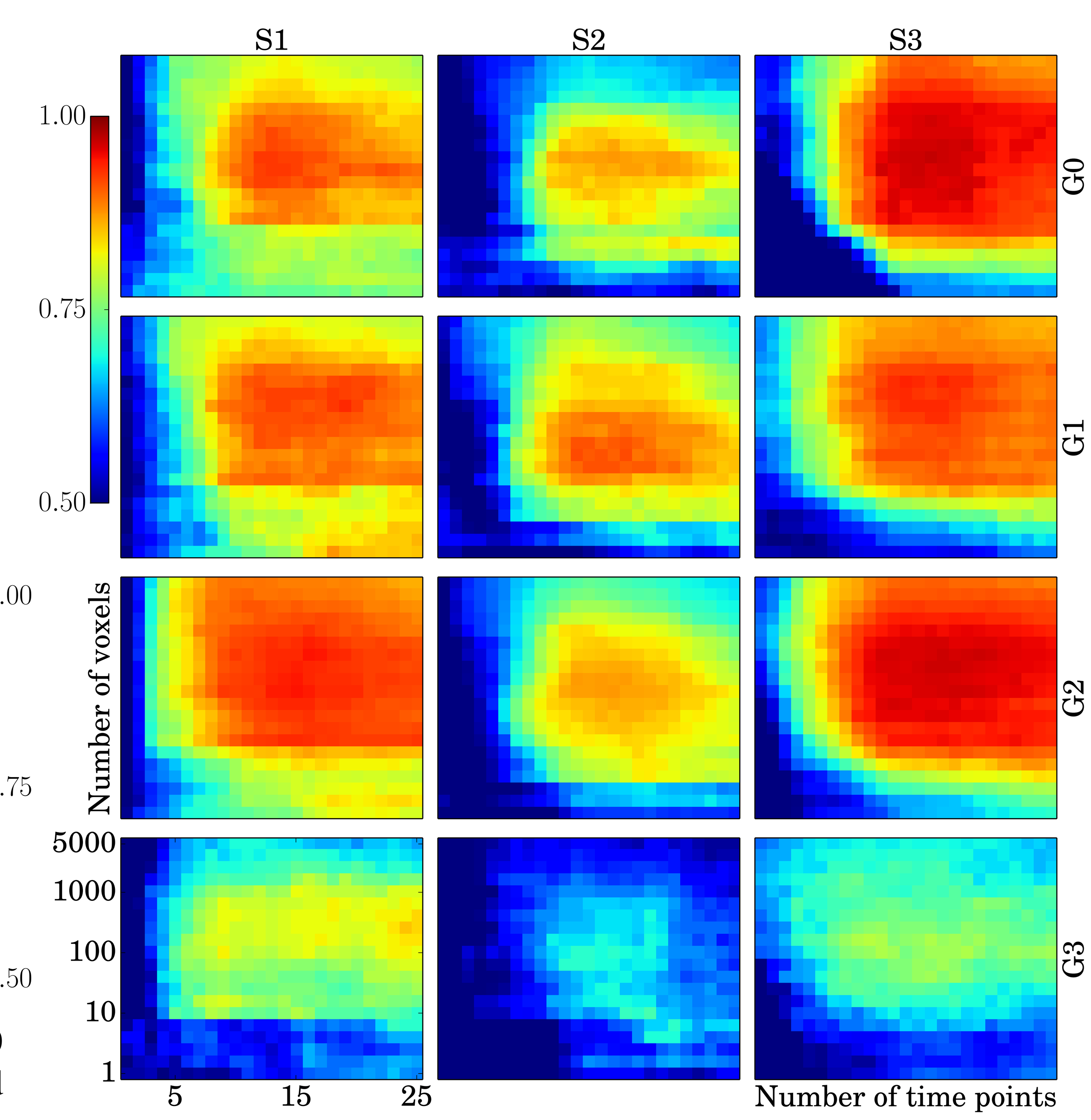
**(TR, BL, BR) Confusion matrices.** Indicating cross-validated accuracies of all task combinations and three subjects. Features: BOLD response, 500 voxels, 13 sec. Linear kernel, L2-regularization, 6-fold cross validated.



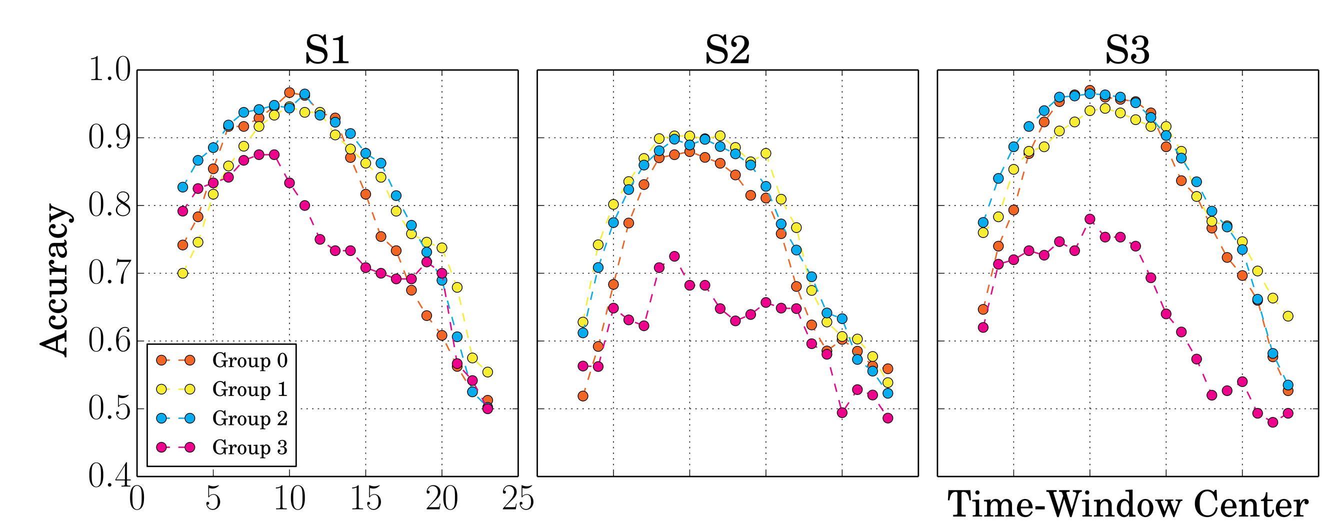

**Classifier performance by group.** Median distribution of all binary pairs within each group. 50 out of the 500 most reliable voxels (high R2) were selected at random. Group 3 displays significantly lower performance (95% median C.I.).




**Accuracy vs. Reliability.** Voxels drawn from a 1000-voxel-window for decreasing R2. All subjects and task groups display exponential decrease in accuracy with voxel rank.




**Grid search over feature space.** Uses a time interval starting at t=0, and voxel interval starting at highest $R^2$ rank. Peak accuracy requires approx. 0 to 12 -14sec of time-series and a few hundred voxels.




**Optimal time window.** A 5-sec moving time window over BOLD responses suggest that 7.5--12.5sec (late-stage) dynamics capture inter-task differences.

## Methods

Three subjects (S1, S2, S3) performed a set of ten tasks involving five different motions while holding a 0.05kg (light) or 0.5kg (heavy) object. Each task was repeated 12 times in random order. We use linear SVM with L2-regularization and compute prediction accuracies using 6-fold cross validation. Features are concatenated time series as in [2].

## References

[1] Meier JD, Graziano MSA et.al. (2008) Complex organization of human primary motor cortex: A high-resolution fMRI study. J. Neurophysiol., 100: 1800-1812.

[2] Pereira, F., Mitchell, T., and Botvinick, M. (2009) "Machine learning classifiers and fMRI: a tutorial overview." Neuroimage 45.1: S199-S209.

## Appendix

fMRI : Gradient echo EPI, 2.5 x 2.5 x 2.5 $mm^3$ voxels, 1.57s TR, 28ms TE, 72° flip angle. Preprocessing: Slice time and motion correction (SPM), spatial undistortion using fieldmaps, and denoising with GLMDenoise.
Subjects: 2 male, 1 female. 21-30 y. All right handed. Consent obtained in advance on IRB protocol.
Scanner: GE Discovery MR750.
SVM: Matlab and LIBSVM v3.17.

## Acknowledgment

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