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Computing linear approximations to nonlinear neuronal responses

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Many methods used to analyze neuronal response assume that neuronal activity has a fundamentally linear relationship to the stimulus. For example, analyses based on spike-triggered average or generalized linear models (GLMs) assume that the only nonlinearity is the spiking nonlinearity, e.g. a threshold. However, many neurons have a response pattern that exhibits a more fundamental nonlinearity. For example, the nonlinearity of a neuron which is highly selective to a small class of images or songs may not be captured by a GLM because such selectivity implies strong sensitivity to multiple directions in stimulus space. Nonetheless, the response of such a neuron can be captured by a linear model if the stimulus is constrained to be close to some stimulus of interest, and the local linear approximation gives insight into neuronal behavior near that stimulus. We derive a modification of the spike-triggered average to compute such local linear approximations and demonstrate via simulation how they can reveal hidden features of the neuron's response.