

A very general linear-nonlinear model for the spatio-temporal characterization of visual cells from natural images

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Abstract

The large dimensionality of inputs greatly complicates the characterization of visual cells from input-output data. To make such characterizations possible, dimensionality reduction techniques are needed. A common approach is to assume that the cell response follows a linear-nonlinear model. A generic version of this model has too many parameters. So, previous methods have estimated simplified versions of this model. Also, some of these methods can only be used with Gaussian noise inputs. Here, instead of simplifying the model, we develop the extended Projection Pursuit Regression (ePPR) algorithm that, using an efficient optimization strategy, allows the estimation of all the parameters of the generic linear-nonlinear model from natural images.

We first test the feasibility of ePPR with a model of a complex cell having suppressive filters. We then use ePPR to characterize V1 cells in anesthetized cats. By showing that a first ePPR model estimated from responses of a cortical complex cell to natural images is very similar to a second ePPR model estimated from responses of the same cell but to random images, we verify that ePPR can characterize visual cells using arbitrary stimuli. Despite their similarity, only the ePPR model estimated from natural images showed late suppressive components, suggesting that the observable response properties of visual cells depend on the statistics of the inputs used to probe them. Moreover, ePPR successfully characterized a simple cell, verifying that it can be used to model a wide variety of visual cells. For both type of stimuli and both types of cells, the predictions of the ePPR model are substantially better than those of previous methods.

To our knowledge ePPR is the first algorithm to estimate, from natural and random images, a generic linear-nonlinear models that is spatio-temporal, uses two-dimensional images as inputs, and whose linear component contains more than one filter.

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