Functional magnetic resonance imaging (fMRI) data measures the blood oxygen level-dependent (BOLD) signal in the brain while a subject performs one or more tasks. The BOLD signal is a proxy for neural activity, and researchers often want to know whether and how neural activity differs between different groups of subjects performing the same task, or how it differs for different tasks within a single subject. For the former question, discovering regions of the brain for which neural activity differs for a group of healthy subjects vs. subjects diagnosed with a disorder such as schizophrenia can provide insight into the underlying biological basis of the disorder. For the latter question, one can determine which regions of the brain are activated when performing one task vs. another. One way to analyze fMRI data to answer such questions is through a logistic regression model, where the response is an indicator for the group of subjects or task and the predictor is the image itself. A major challenge for fitting such a model is that the image is a multidimensional array, called a tensor, containing tens of thousands of elements, called voxels. Because there is a parameter associated with each voxel, fitting the model entails estimating tens of thousands of parameters with a typical sample size on the order of hundreds of subjects. We propose to reduce the dimensionality of the problem by assuming the parameter tensor is orthogonally decomposable, enabling us to penalize the so-called tensor "singular values" to obtain a low rank estimate. We develop algorithms based on projected gradient descent and the proximal gradient method to estimate the model. We illustrate the proposed method on the Visual Object Recognition data through an exercise in intra-subject visual stimulus decoding.

KEYWORDS: tensor regression, orthogonally decomposable, nuclear norm, low rank, fMRI data