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Subject: Visual Model



Advanced Topics in Neuroscience - Dr. Ali Ghazizadeh

Assignment 9

Aim: Study the sparse representation of natural image statistics as the receptive fields of simple cells in primary visual cortex.

Several computational studies conducted since Barlow made this proposal have demonstrated more concretely the relationship between sparsity and the statistics of natural scenes. In the visual system, for example, the images that fall upon the retina when viewing the natural world have a relatively regular statistical structure, which arises from the contiguous structure of objects and surfaces in the environment. Field has shown that the receptive field properties of simple-cells in primary visual cortex (V1) are well suited to this structure, in that they produce sparse representations. Olshausen had subsequently showed that, when the receptive fields of an entire population of neurons are optimized to produce sparse representations, that the set of receptive fields that emerge resemble those of simple-cells.

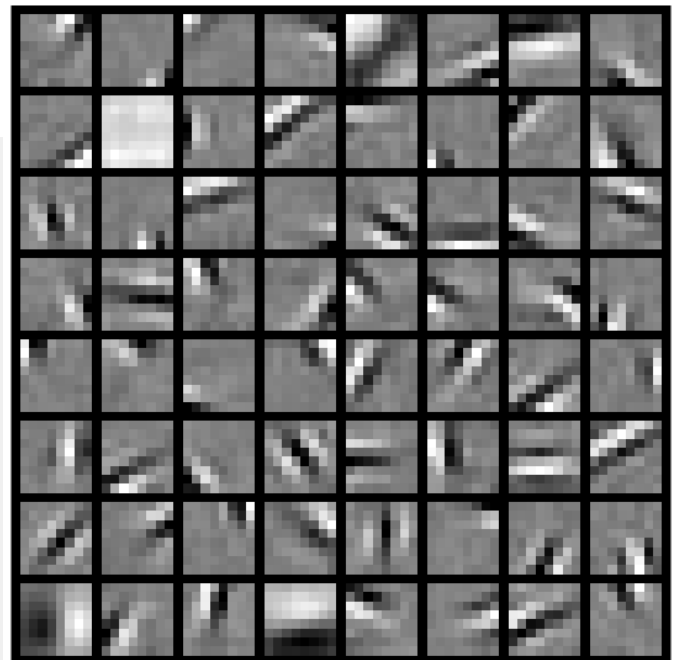
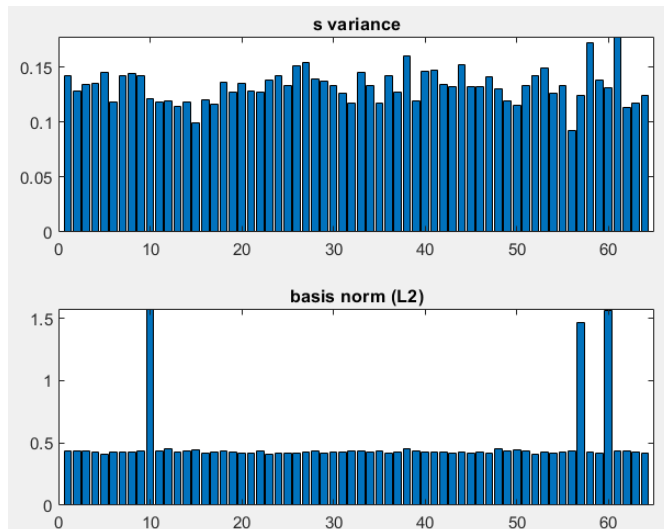
part 1:

Simulate sparse basis functions of the natural images:

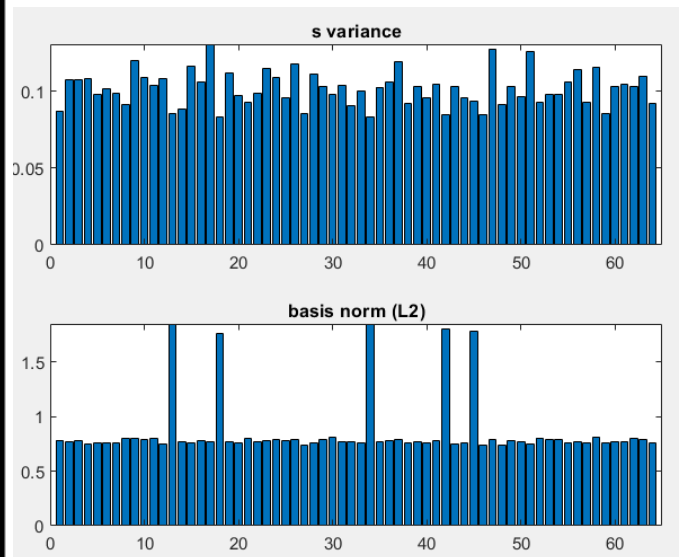
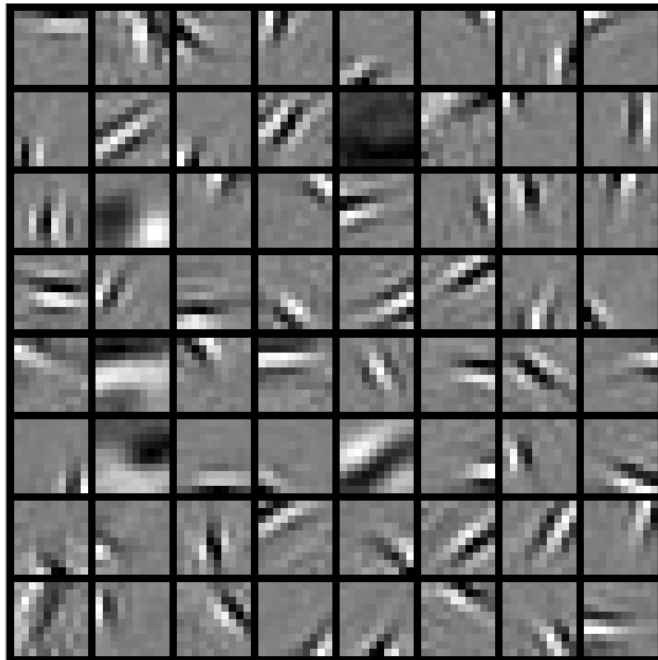
Using the IMAGES.mat file, which contains 10 natural images, and the method proposed by Olshausen, simulate the basis functions for sparse representation of natural images. Actually, you should simulate part “a” of the figure 4 in the paper “Olshausen, Field 1996”. In order to solve the conjugate gradient descent part of the algorithm, you could use any preferred package or code.

Answer:

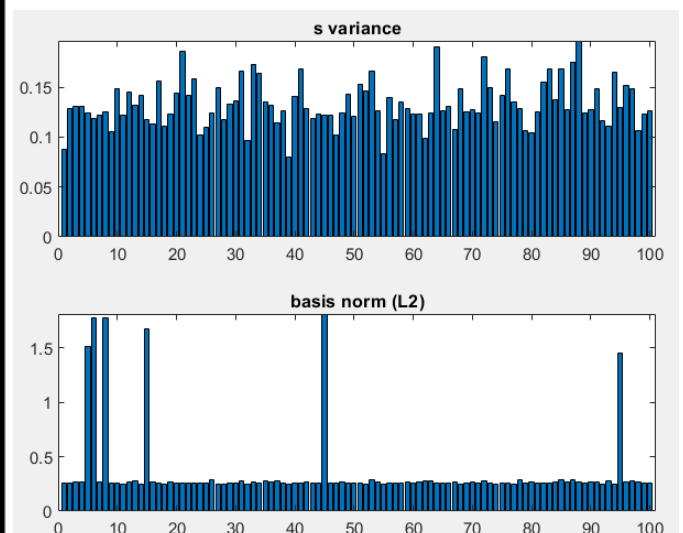
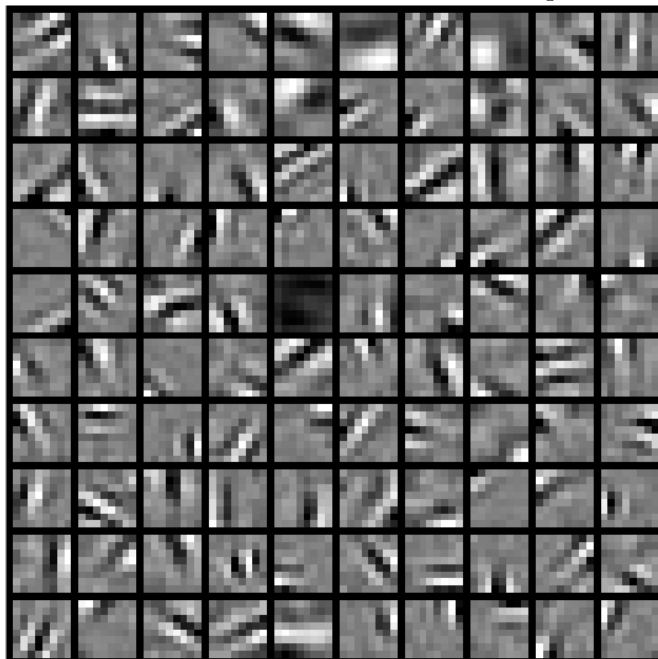
64 Basis functions. Each function has 64 pixels:



64 Basis functions. Each function has 100 pixels:



100 Basis functions. Each function has 64 pixels:



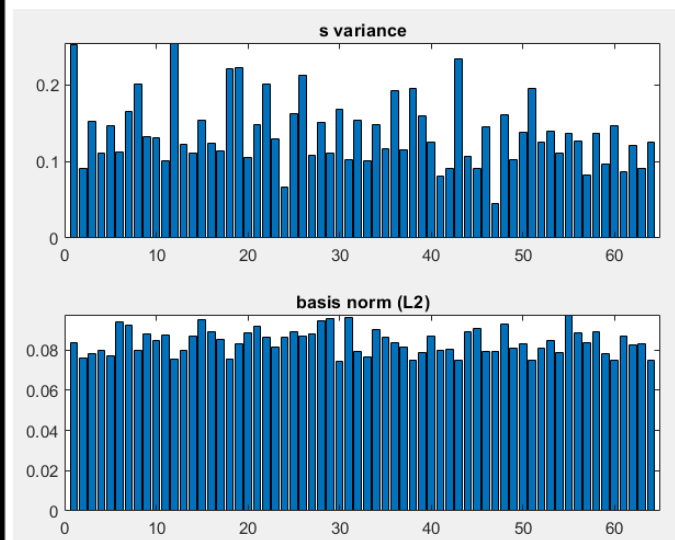
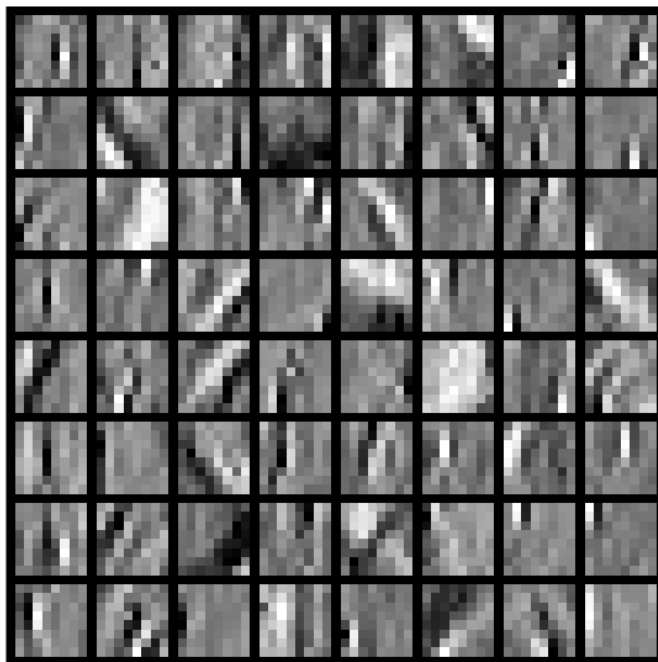
part 2:

Study the effect of different datasets:

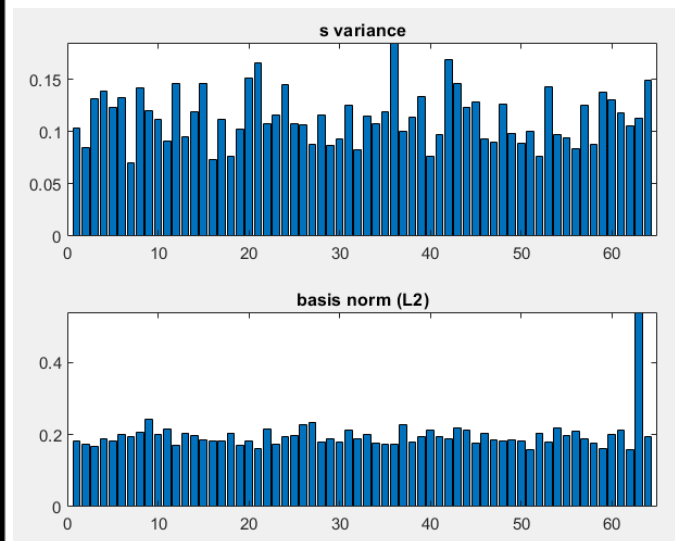
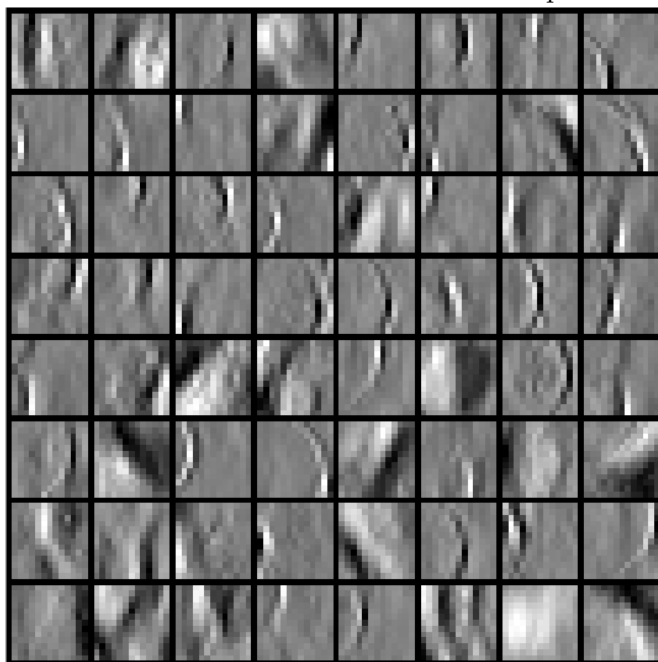
here we try to find the basis functions for different datasets and compare them with the basis drawn from the natural images.

Yale Face data set

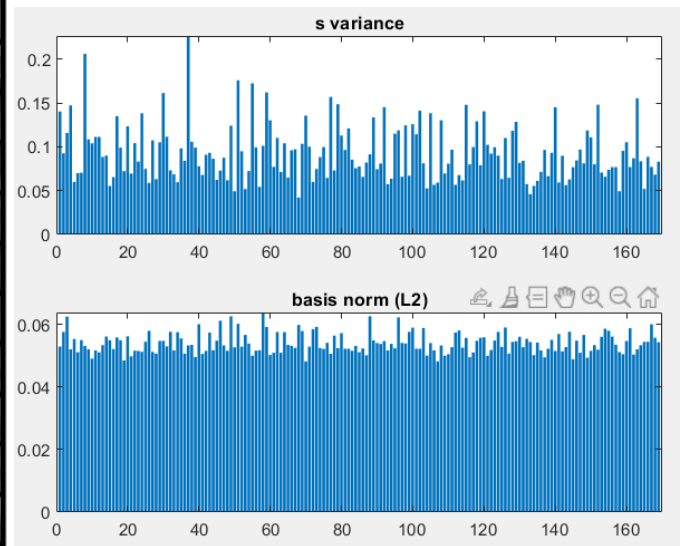
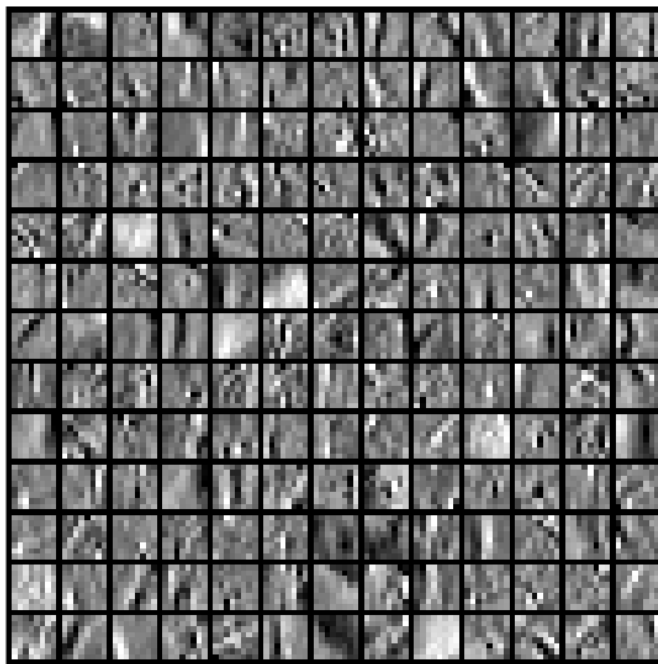
64 Basis functions. Each function has 64 pixels:



64 Basis functions. Each function has 169 pixels:

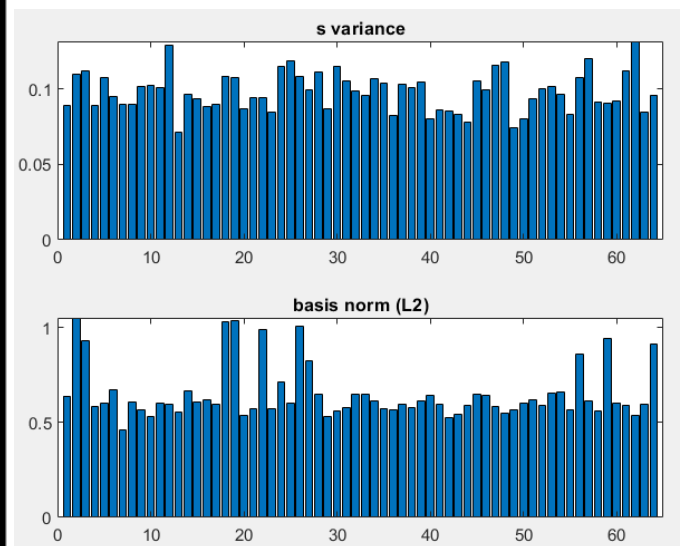
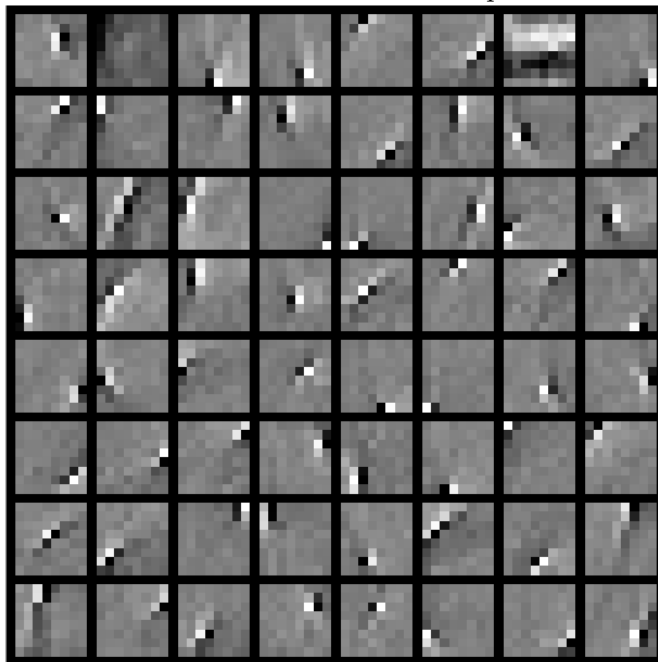


169 Basis functions. Each function has 64 pixels:

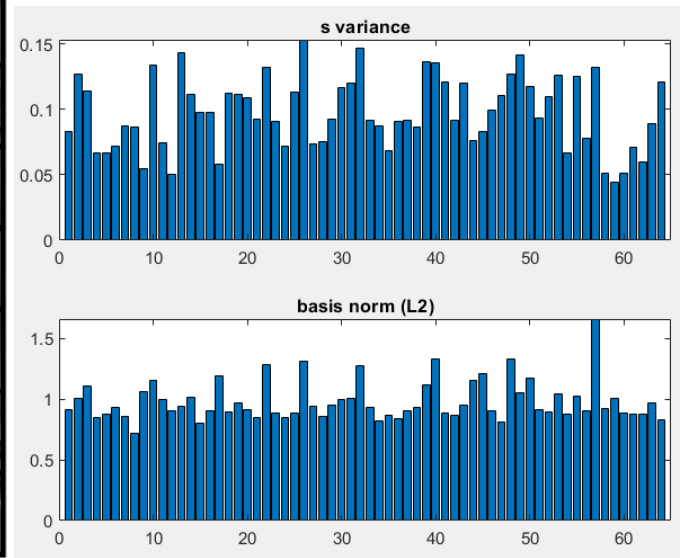
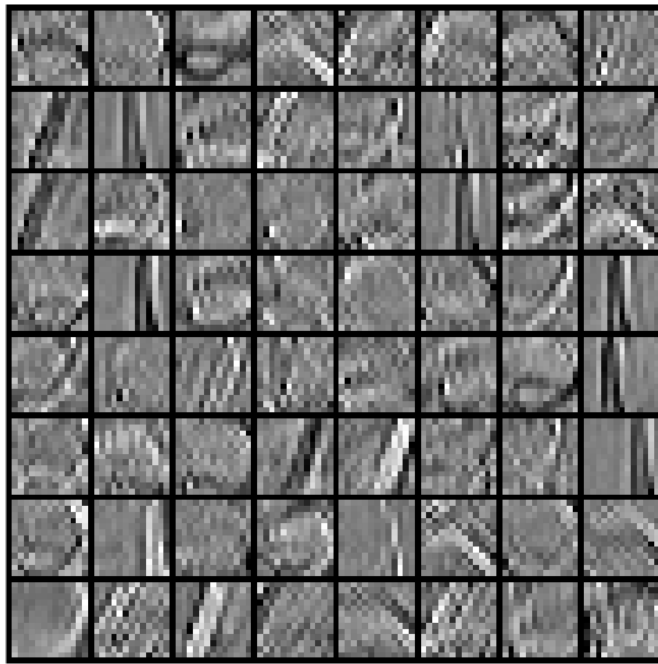


MNIST data set

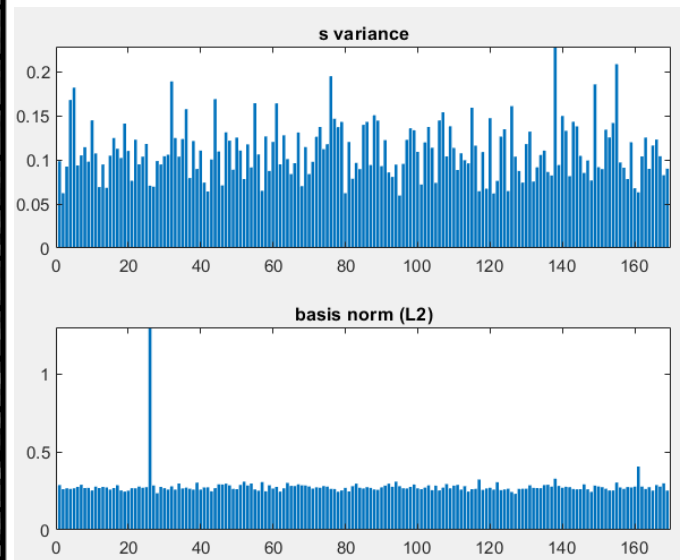
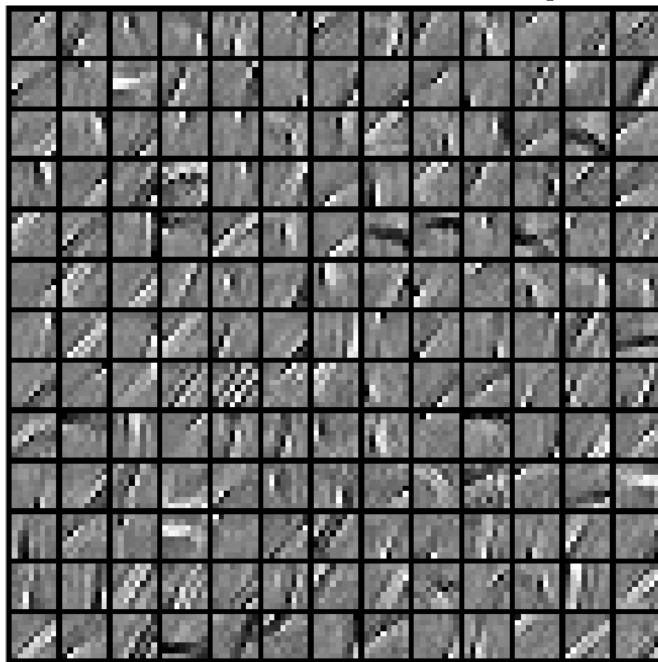
64 Basis functions. Each function has 64 pixels:



64 Basis functions. Each function has 169 pixels:



169 Basis functions. Each function has 64 pixels:



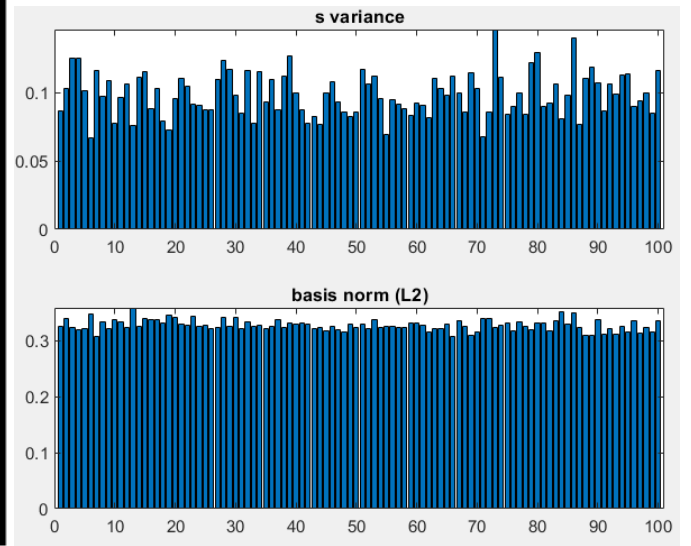
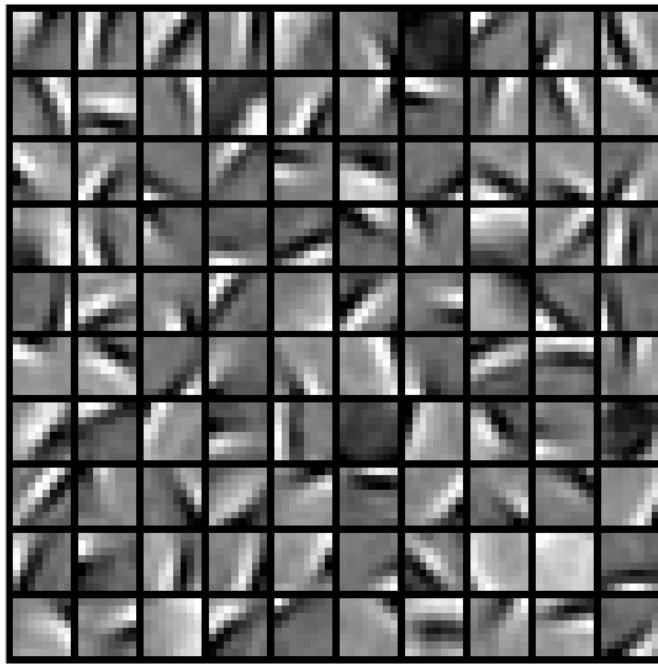
part 3:

Study the dynamics of the sparse coefficients:

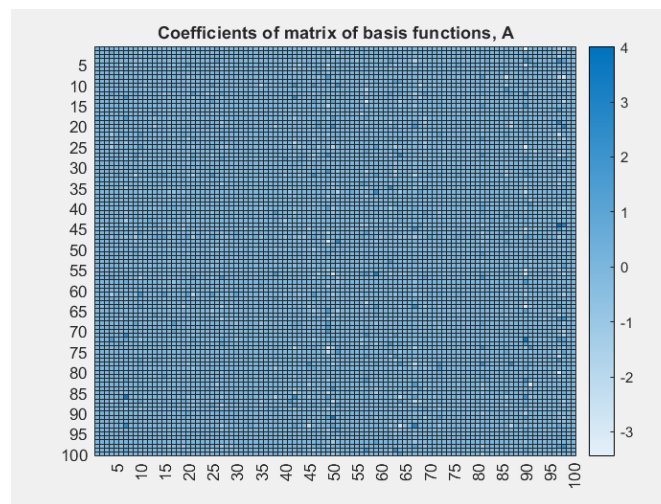
Find the sparse coefficients for the BIRD video in the attachment. Select each 10 frames as one patch for finding the basis function and the sparse representations. How the sparse coefficients change across time?

Answer:

Basis functions for first 10 frames:



Coefficients after last iteration:



A video is in the zip file to show the changes of coefficients over time.