In The Name Of God

HW09

Advanced Neuroscience

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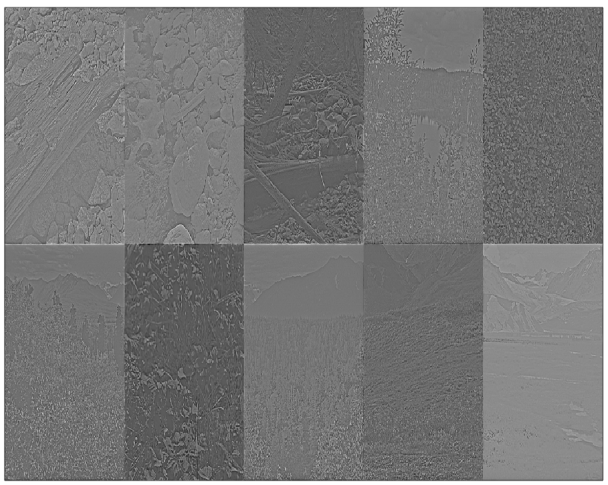
97102099

■ Part1 - Simulate sparse basis functions of the natural images

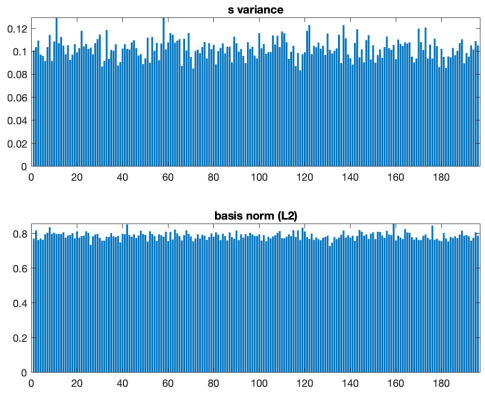
□ Paper images

(a) Raw images

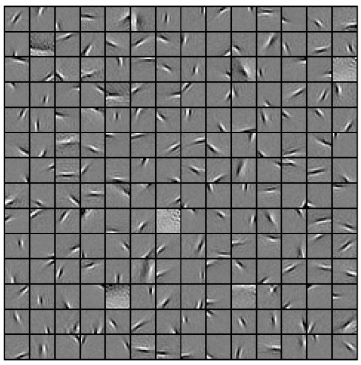


(b) Whitened images

Figure 1: Raw and whitened images for calculating the basis functions

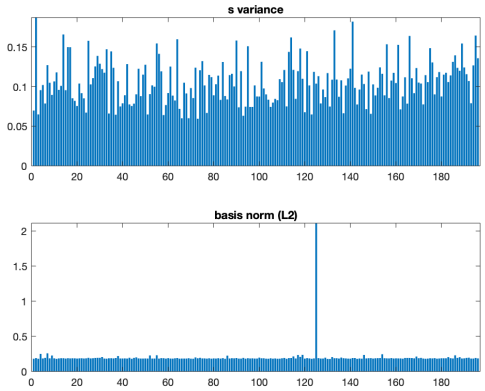


(a) Shape of the basis function

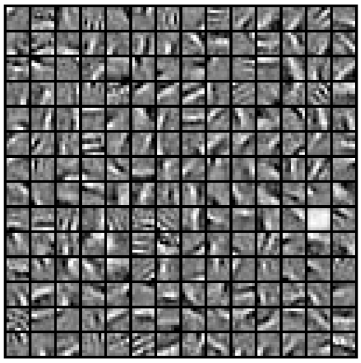


(b) Norm and sample variance of the basis functions

Figure 2: Shape, norm, and variance of the basis functions - 196 Basis functions on 16*16 image patches - 5000 trials

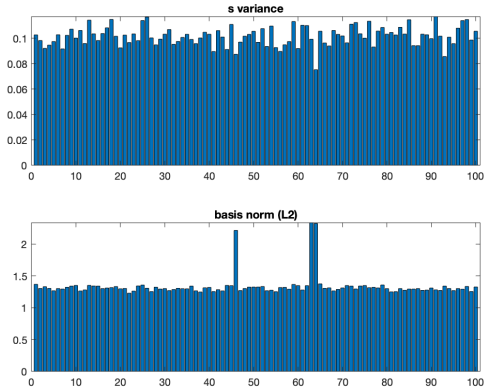


(a) Shape of the basis function

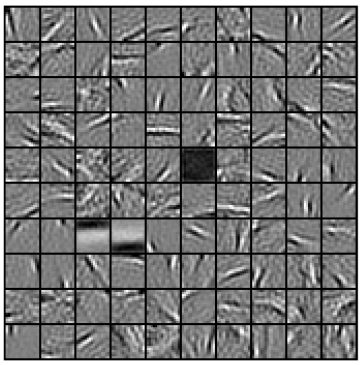


(b) Norm and sample variance of the basis functions

Figure 3: Shape, norm, and variance of the basis functions - 196 Basis functions on 8*8 image patches - 5000 trials



(a) Shape of the basis function



(b) Norm and sample variance of the basis functions

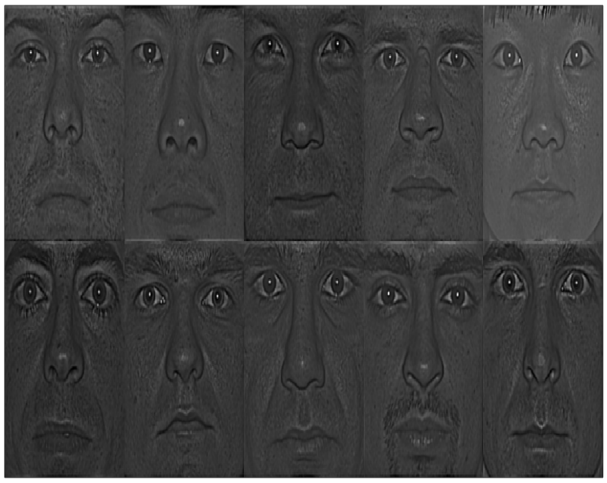
Figure 4: Shape, norm, and variance of the basis functions - 100 Basis functions on 16*16 image patches - 5000 trials

Smaller patches will lead to less sparse basis functions, because a small patch will cover a small part of the image, so there won't be so much color and edges in this small part. The smaller patches have less spectrum variety and fewer intensities, so the basis functions won't be so sparse. This theory is obvious by comparing Figures 2 and 3. Also, a bigger number of basis functions will make each of them sparser. In this case, there are more basis functions to model patches so the basis functions would be sparser. You can see this by comparing Figures 2 and 4.

■ Part2 - Study the effect of different datasets

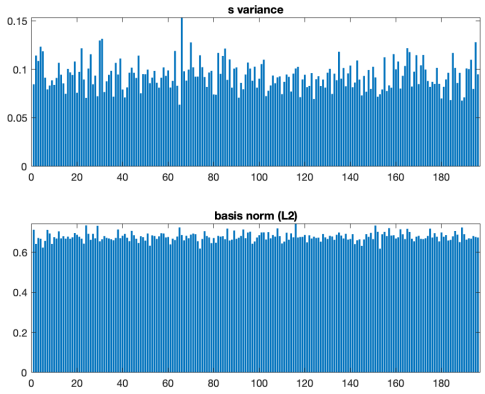
□ Yale dataset images

(a) Raw images

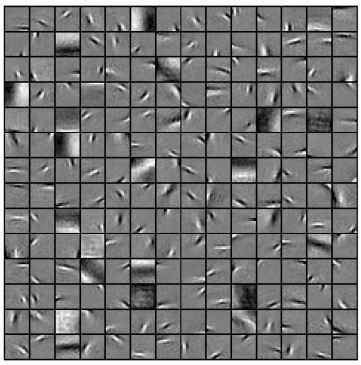


(b) Whitened images

Figure 5: Raw and whitened images for calculating the basis functions

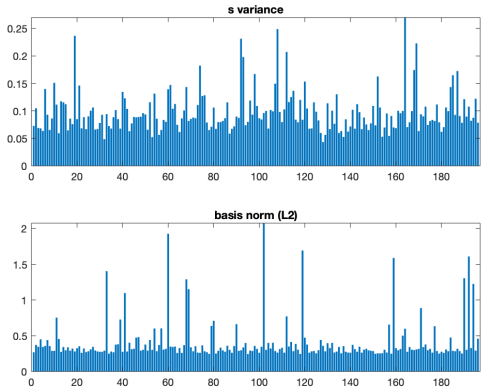


(a) Norm and sample variance of the basis functions

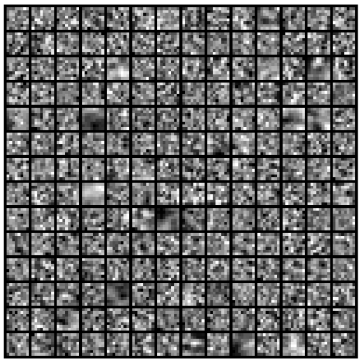


(b) Shape of the basis function

Figure 6: Shape, norm, and variance of the basis functions - 196 Basis functions on 16*16 image patches - 5000 trials

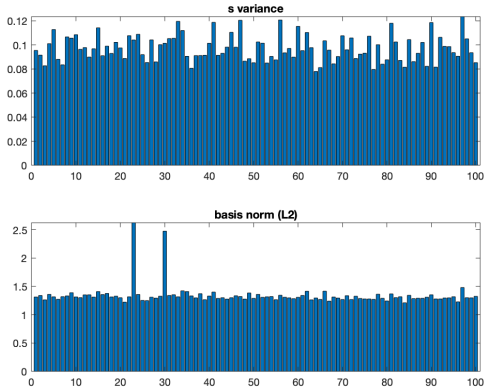


(a) Norm and sample variance of the basis functions

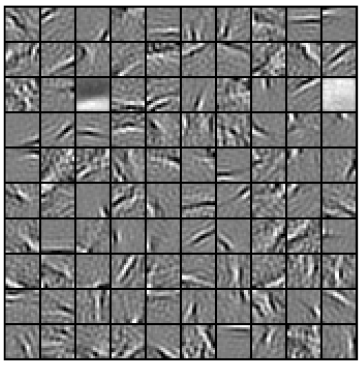


(b) Shape of the basis function

Figure 7: Shape, norm, and variance of the basis functions - 196 Basis functions on 8*8 image patches - 5000 trials



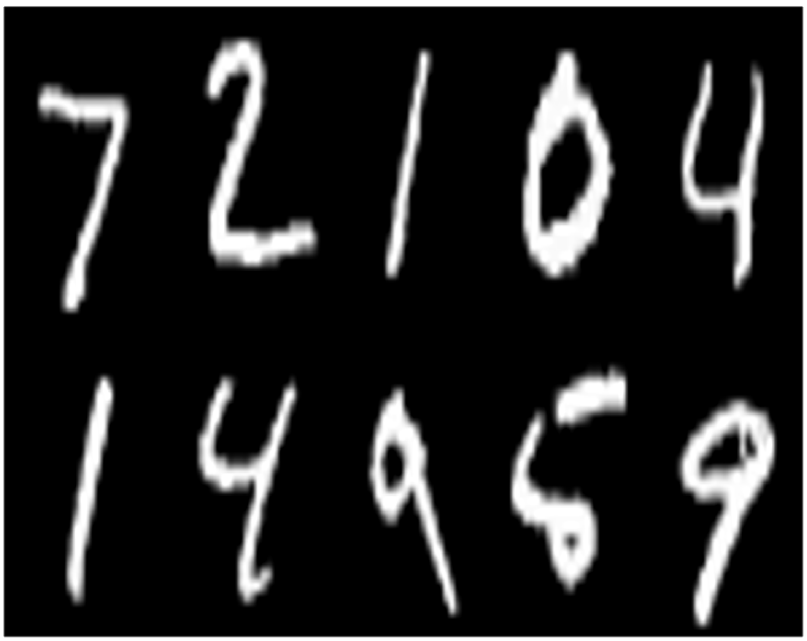
(a) Norm and sample variance of the basis functions



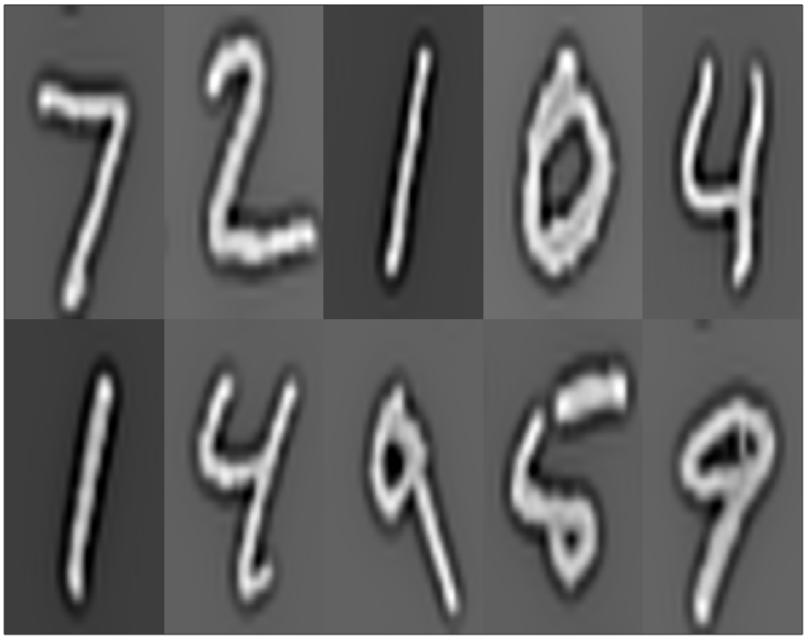
(b) Shape of the basis function

Figure 8: Shape, norm, and variance of the basis functions - 100 Basis functions on 16*16 image patches - 5000 trials

□ MNIST dataset images

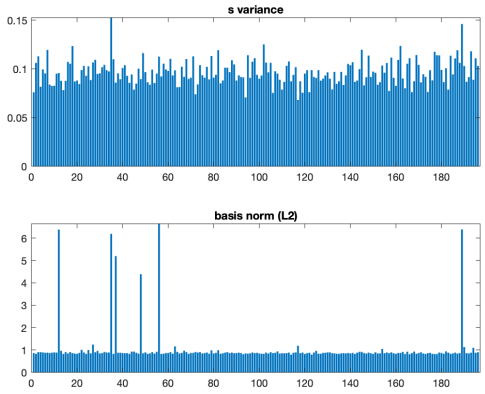


(a) Raw images

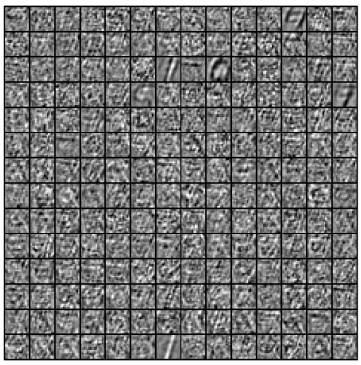


(b) Whitened images

Figure 9: Raw and whitened images for calculating the basis functions

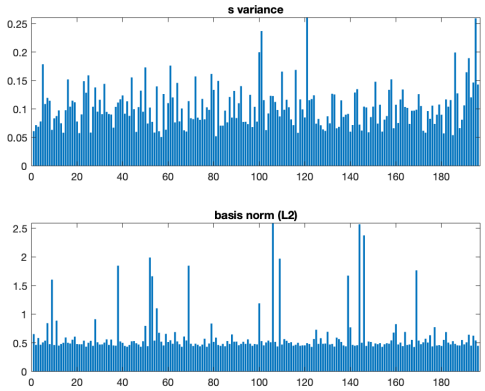


(a) Norm and sample variance of the basis functions

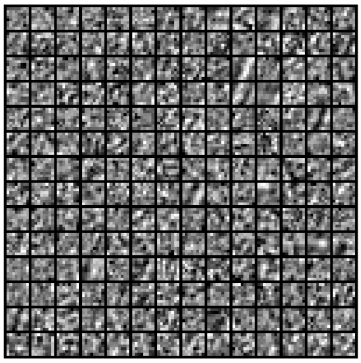


(b) Shape of the basis function

Figure 10: Shape, norm, and variance of the basis functions - 196 Basis functions on 16*16 image patches - 5000 trials

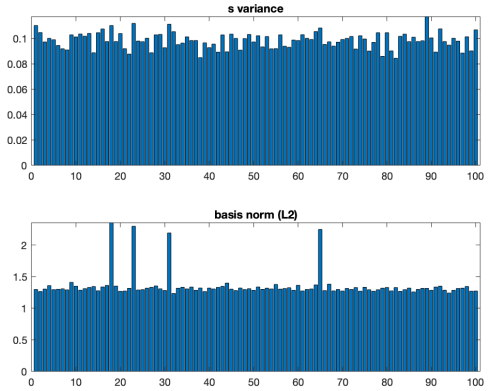


(a) Norm and sample variance of the basis functions

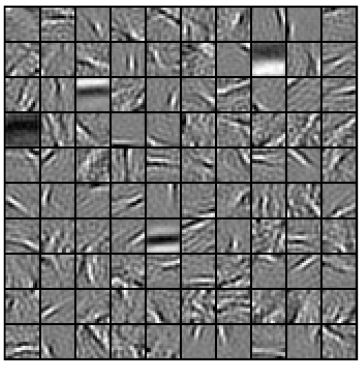


(b) Shape of the basis function

Figure 11: Shape, norm, and variance of the basis functions - 196 Basis functions on 8*8 image patches - 5000 trials



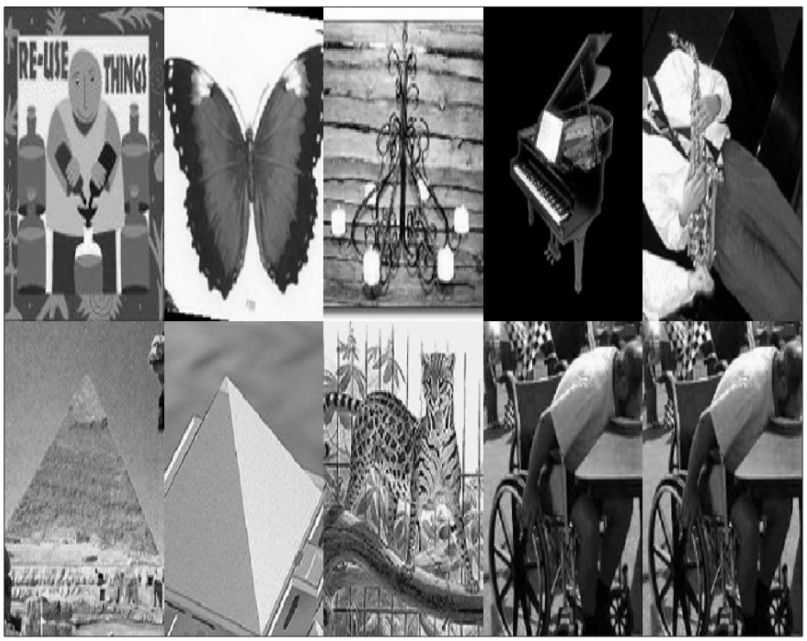
(a) Norm and sample variance of the basis functions



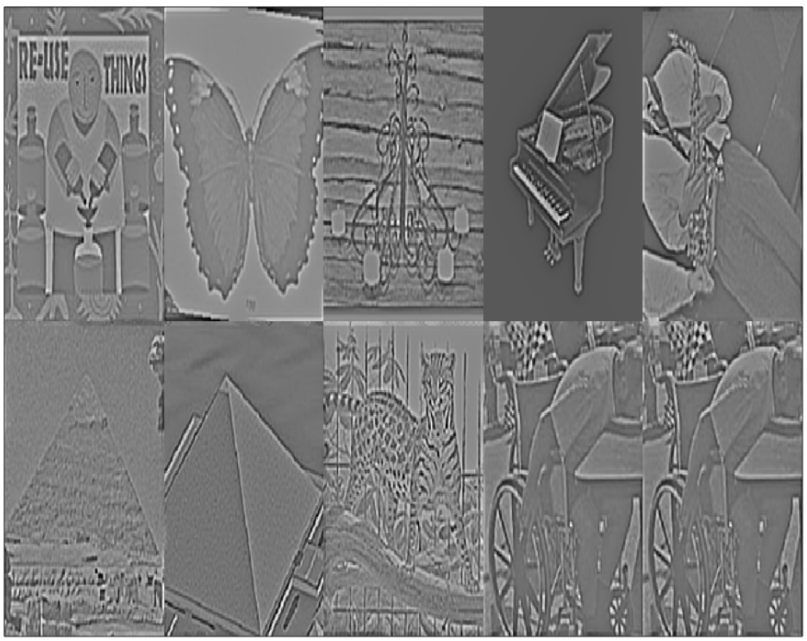
(b) Shape of the basis function

Figure 12: Shape, norm, and variance of the basis functions - 100 Basis functions on 16*16 image patches - 5000 trials

□ Caltech 100 dataset images

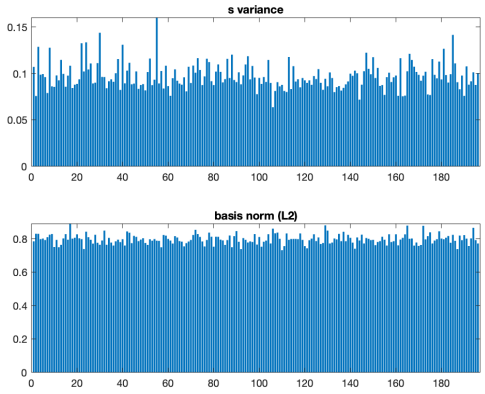


(a) Raw images

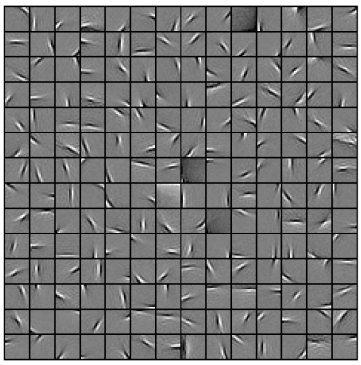


(b) Whitened images

Figure 13: Raw and whitened images for calculating the basis functions

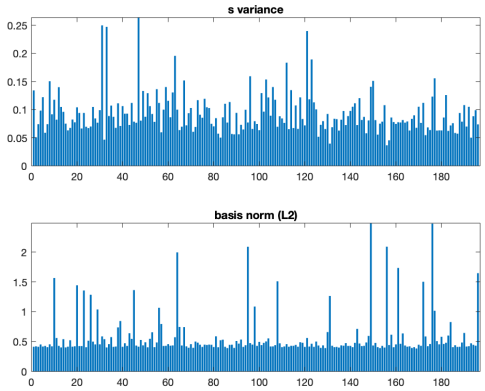


(a) Norm and sample variance of the basis functions

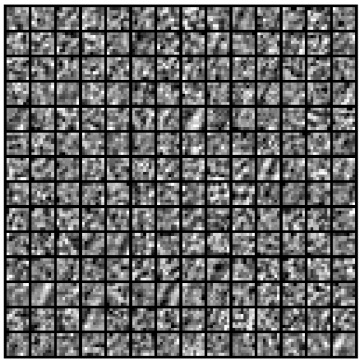


(b) Shape of the basis function

Figure 14: Shape, norm, and variance of the basis functions - 196 Basis functions on 16*16 image patches - 5000 trials

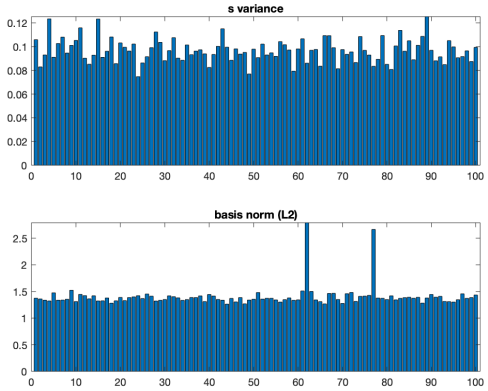


(a) Norm and sample variance of the basis functions

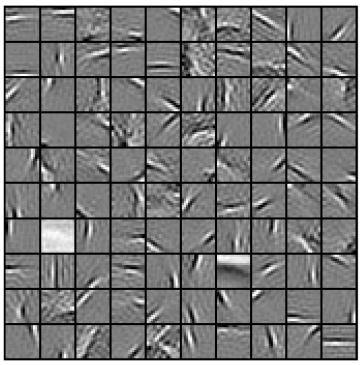


(b) Shape of the basis function

Figure 15: Shape, norm, and variance of the basis functions - 196 Basis functions on 8*8 image patches - 5000 trials



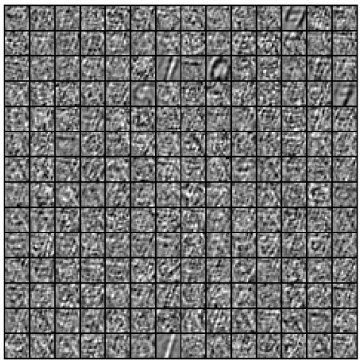
(a) Norm and sample variance of the basis functions



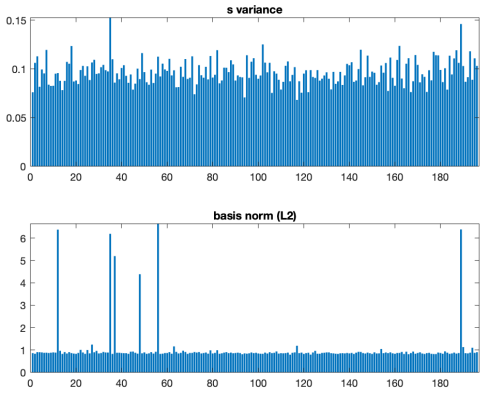
(b) Shape of the basis function

Figure 16: Shape, norm, and variance of the basis functions - 100 Basis functions on 16*16 image patches - 5000 trials

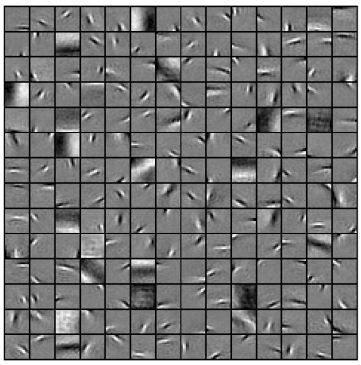
As can be seen in Figures 5 to 16, basis functions of some of the datasets are way more sparse in comparison with the other datasets. It is because these datasets have natural images. Figures 6 and 10 are for *Yale* and *MNIST* datasets and Figure 14 is for *Caltech110* dataset. Basis functions of the datasets *Yale* and *MNIST* are less sparse in comparison with dataset *Caltech110*. It is because images of the *Caltech110* are more natural and have more intensity and spectrum variety while *Yale* and *MNIST* images are not that natural and have very low variety of intensity and spectrum. Also, Yale images are way more natural than MNIST images because MNIST dataset only contains very high and very low intensities and there aren't so many edges or spectrum variety in its images. Figure 17 shows a comparison between basis functions trained on images of these datasets.



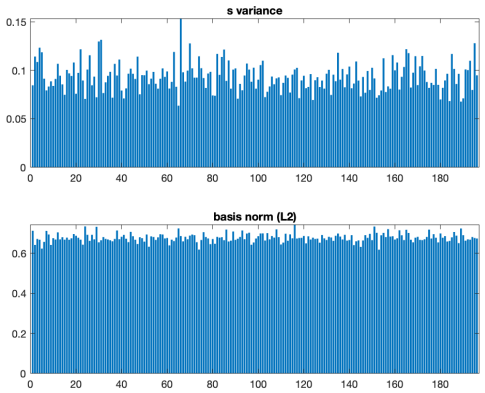
(a) MNIST - Shape



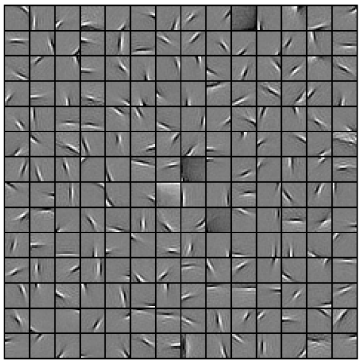
(b) MNIST - Norm and variance



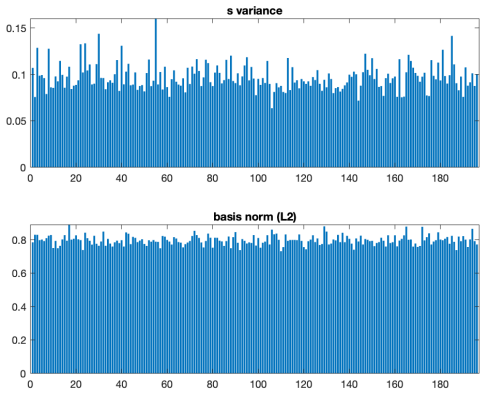
(c) Yale - Shape



(d) Yale - Norm and variance



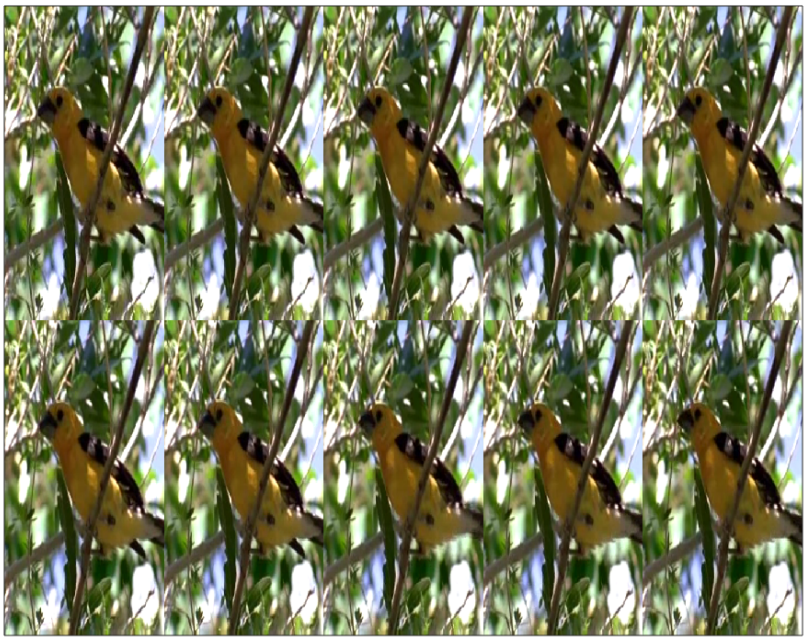
(e) Caltech 110 - Shape



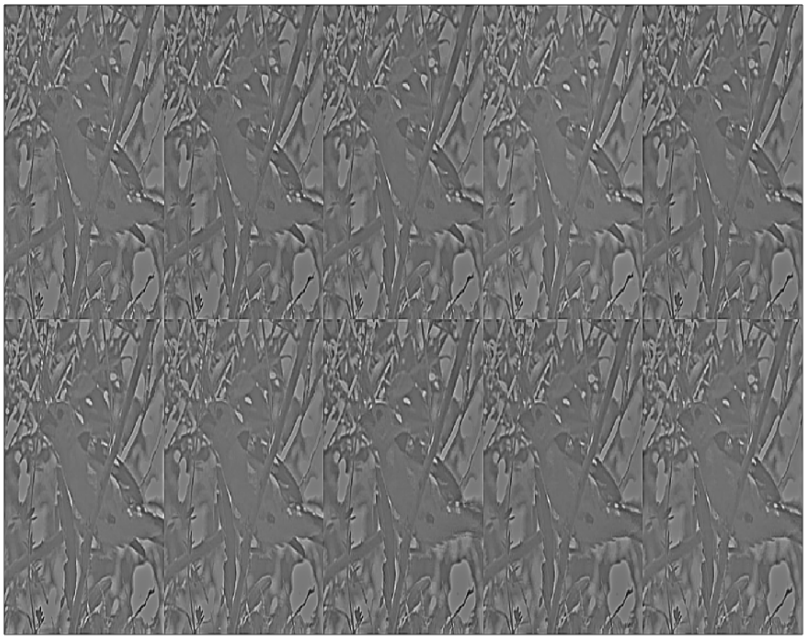
(f) Caltech 110 - Norm and variance

Figure 17: Shape, norm, and variance of the basis functions of different datasets - 196 Basis functions on 16*16 image patches - 5000 trials

■ Part3 - Study the dynamics of the sparse coefficients

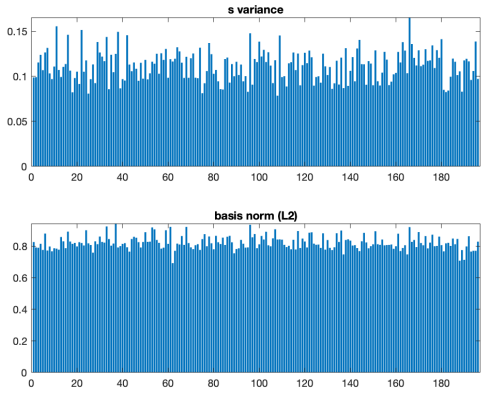


(a) Raw images

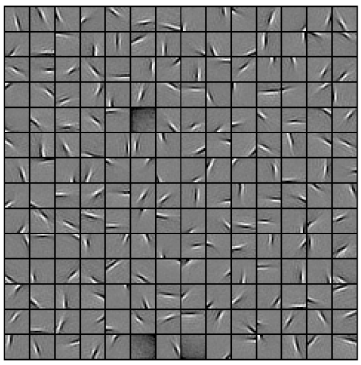


(b) Whitened images

Figure 18: Raw and whitened images for calculating the basis functions

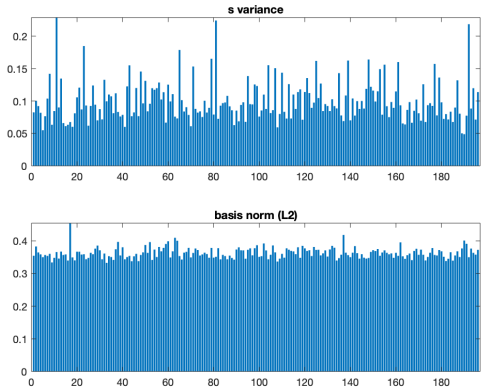


(a) Norm and sample variance of the basis functions

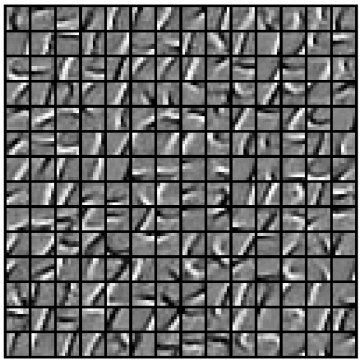


(b) Shape of the basis function

Figure 19: Shape, norm, and variance of the basis functions - 196 Basis functions on 16*16 image patches - 5000 trials

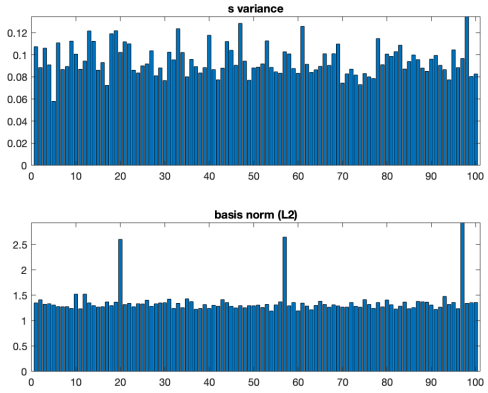


(a) Norm and sample variance of the basis functions

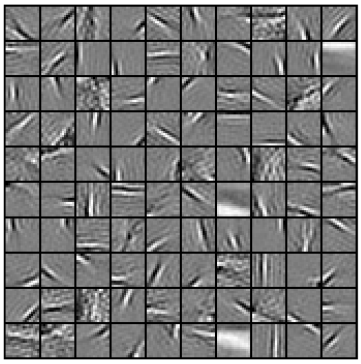


(b) Shape of the basis function

Figure 20: Shape, norm, and variance of the basis functions - 196 Basis functions on 8*8 image patches - 5000 trials



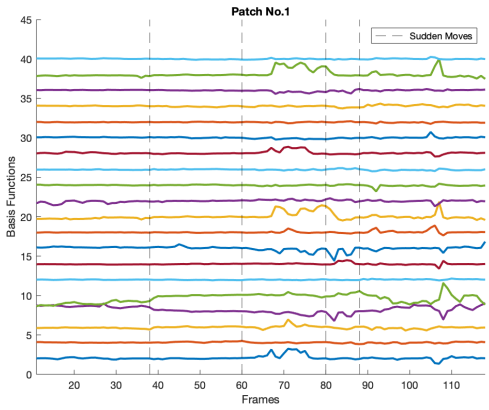
(a) Norm and sample variance of the basis functions



(b) Shape of the basis function

Figure 21: Shape, norm, and variance of the basis functions - 100 Basis functions on 16*16 image patches - 5000 trials

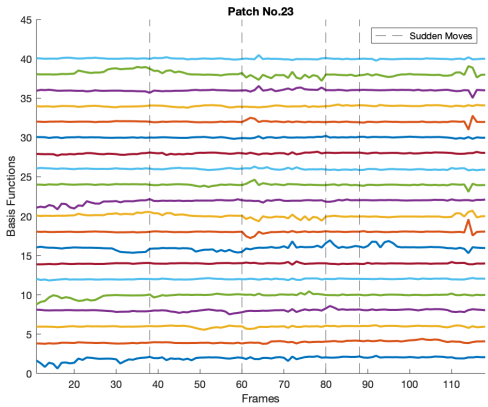
□ Coefficients of basis functions during frames



(a) Coefficients

(b) Patch location

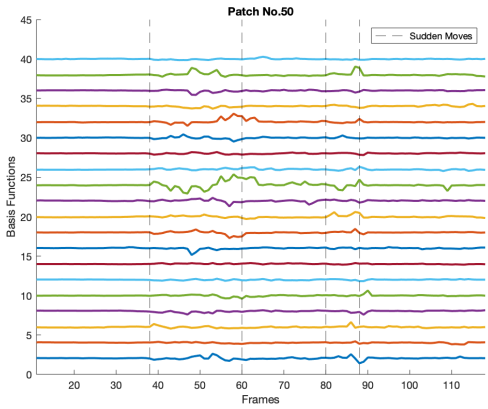
Figure 22: Coefficients of some of the basis functions during the bird video frames for patch No.1



(a) Coefficients

(b) Patch location

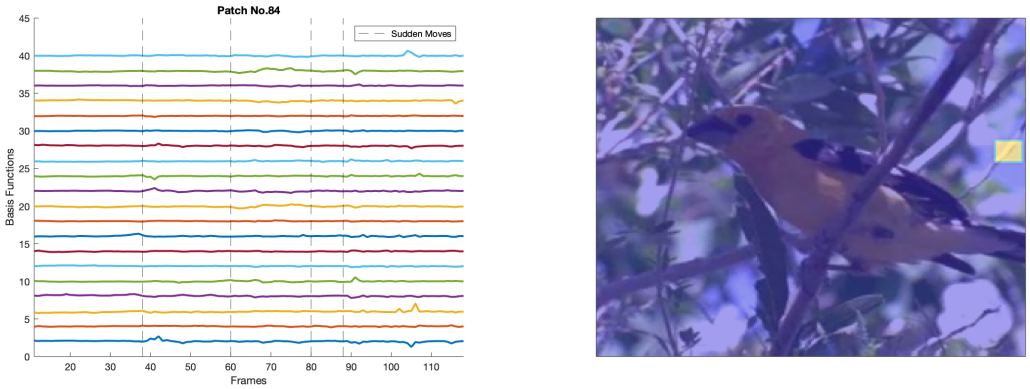
Figure 23: Coefficients of some of the basis functions during the bird video frames for patch No.23



(a) Coefficients

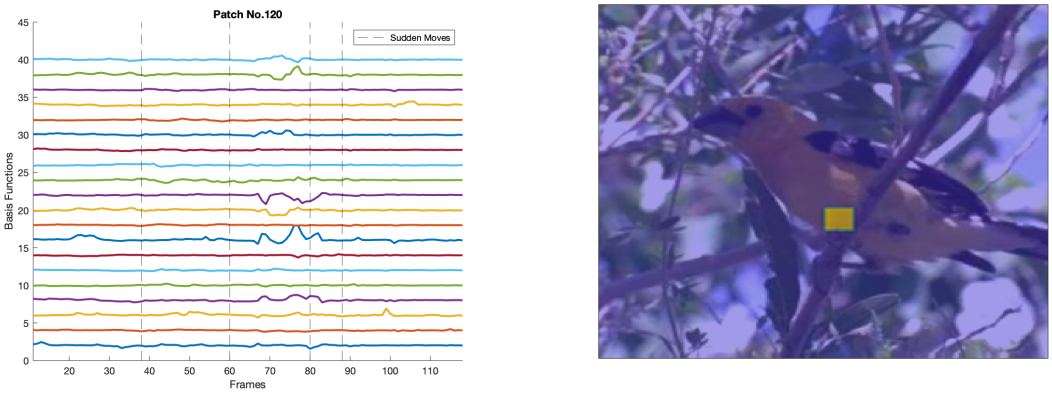
(b) Patch location

Figure 24: Coefficients of some of the basis functions during the bird video frames for patch No.50



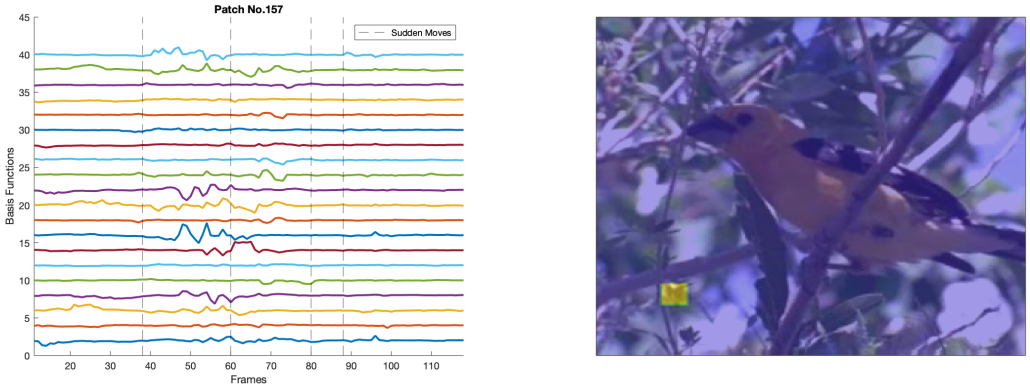
(a) Coefficients (b) Patch location

Figure 25: Coefficients of some of the basis functions during the bird video frames for patch No.84



(a) Coefficients (b) Patch location

Figure 26: Coefficients of some of the basis functions during the bird video frames for patch No.120

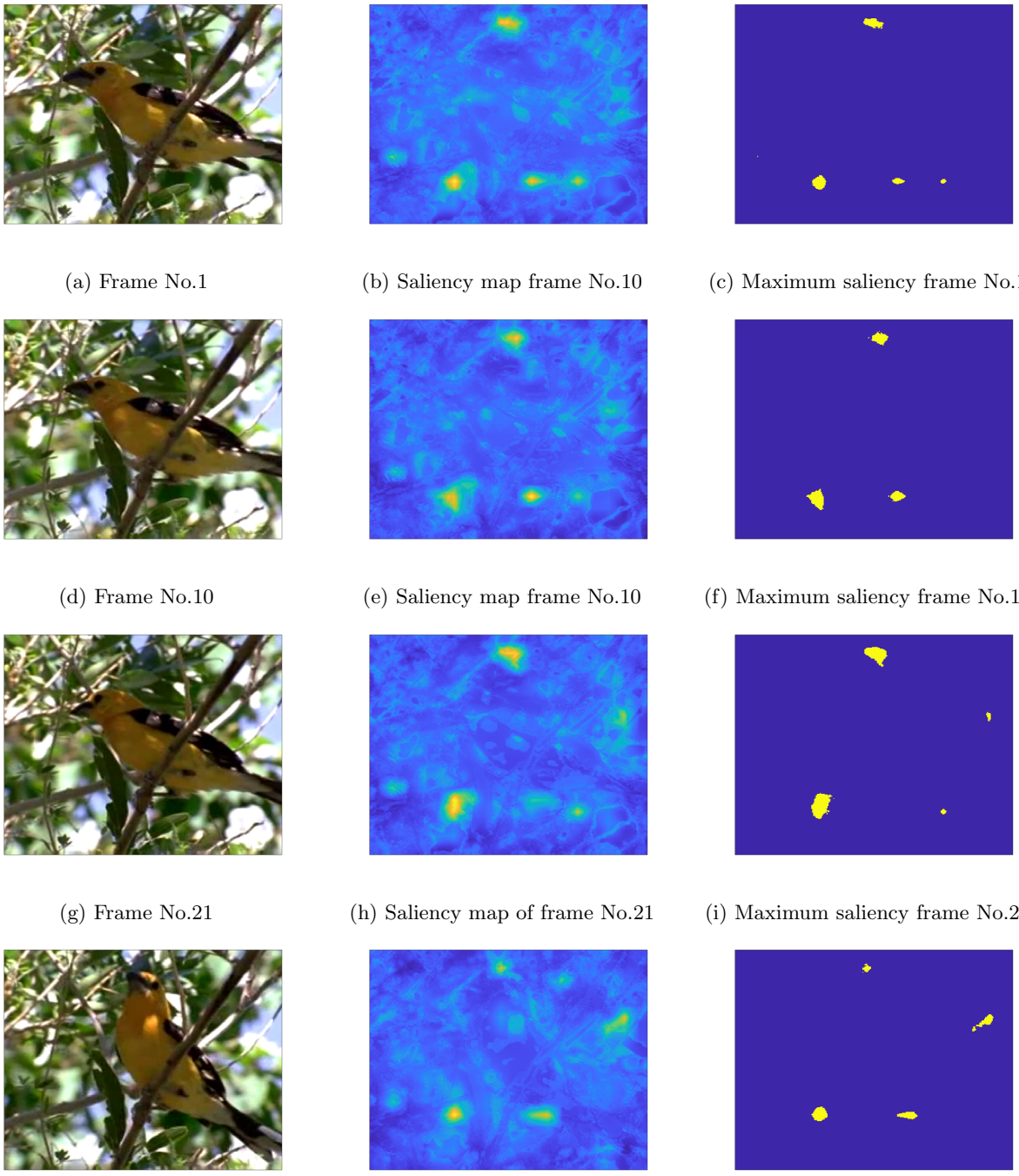


(a) Coefficients (b) Patch location

Figure 27: Coefficients of some of the basis functions during the bird video frames for patch No.157

As expected, the coefficients of the patches which are mostly fixed during the frames won't change much while the coefficients of the patches which are located in the parts of the image that change too much, change more during the frames. This can be seen in Figures 22 to 27. Also, the videos attached to the zip file show this assumption better. These videos were made by finding the k biggest coefficients for each of the patches and then weighted-sum (by coefficients) over all of them. Finally, the obtained sum of the basis functions is overlayed on the frames.

■ Part4 - Study the role of attention models in the basis functions



(a) Frame No.1 (b) Saliency map frame No.10 (c) Maximum saliency frame No.1

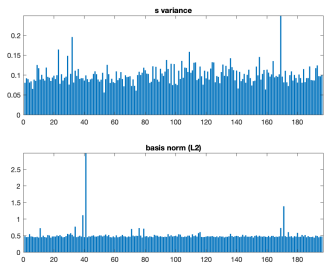
(d) Frame No.10 (e) Saliency map frame No.10 (f) Maximum saliency frame No.10

(g) Frame No.21 (h) Saliency map of frame No.21 (i) Maximum saliency frame No.21

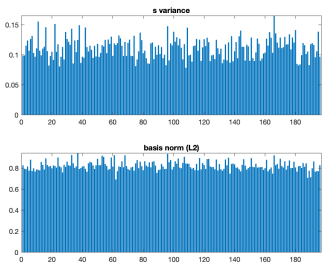
(j) Frame No.41 (k) Saliency map frame No.41 (l) Maximum saliency frame No.41

Figure 28: Saliency map of some of the frames

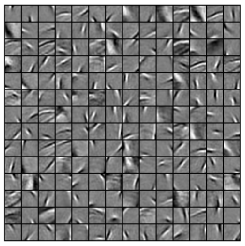
Figure 28 shows the saliency map of some frames of the bird video. Subband, Itti, Color, Torralba, Distance from Center, and Horizon are used as features to calculate the saliency map of the image. As the name of the features implies, most of them use intensity, orientation, and color for extracting the saliency maps.



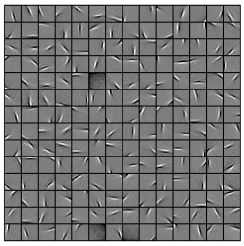
(a) Norm and sample variance of the basis functions - salient patches



(b) Norm and sample variance of the basis functions - random patches

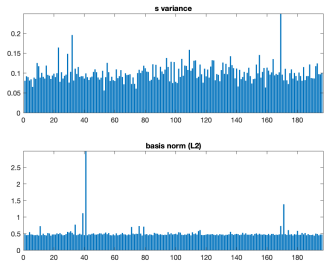


(c) Shape of the basis function - salient patches

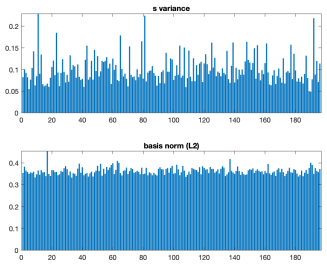


(d) Shape of the basis function - random patches

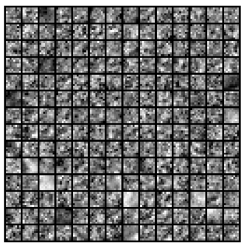
Figure 29: Shape, norm, and variance of the basis functions - 196 Basis functions on 16*16 image patches - 5000 trials



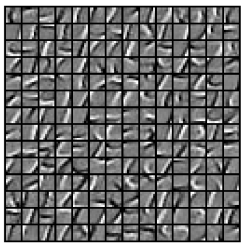
(a) Norm and sample variance of the basis functions - salient patches



(b) Norm and sample variance of the basis functions - random patches

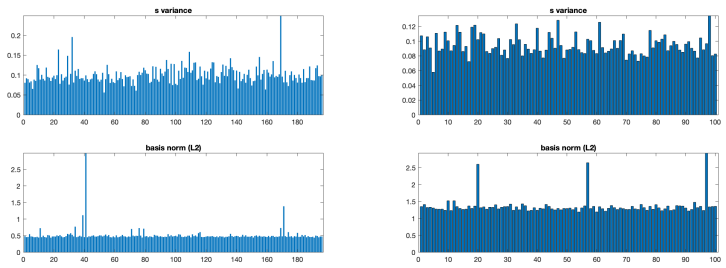


(c) Shape of the basis function - salient patches



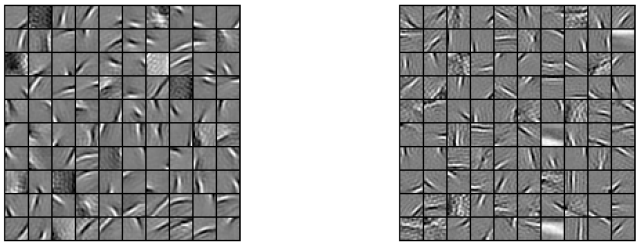
(d) Shape of the basis function - random patches

Figure 30: Shape, norm, and variance of the basis functions - 196 Basis functions on 8*8 image patches - 5000 trials



(a) Norm and sample variance of the basis functions - salient patches

(b) Norm and sample variance of the basis functions - random patches



(c) Shape of the basis function - salient patches

(d) Shape of the basis function - random patches

Figure 31: Shape, norm, and variance of the basis functions - 100 Basis functions on 16*16 image patches - 5000 trials

As can be seen in Figures 29, 30, and 31 the basis functions on patches which were chosen randomly are more sparse. It can be due to that the frames aren't very different and most of the location of salient parts are fixed across the frames. However, the patches from salient parts of the frames will lead to sparser basis functions when the number of basis functions is small. It makes sense because a smaller number of basis functions need more salient patches which contain more intensity, color, edges, and spectrum variety.