

## HW3 Report

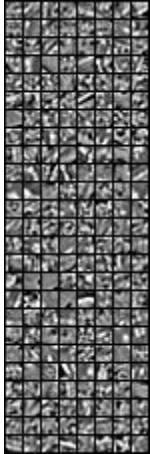
### Numpy:

Difference between analytical and numerical gradient =  $4.3e-11$

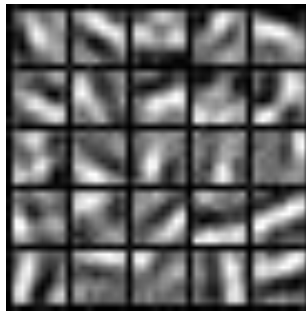
### Natural images:

At iterate 0,  $f = 4.89e+01$

At iterate 400,  $f = 4.77e-01$



patches-natural.jpg



weights-natural.jpg

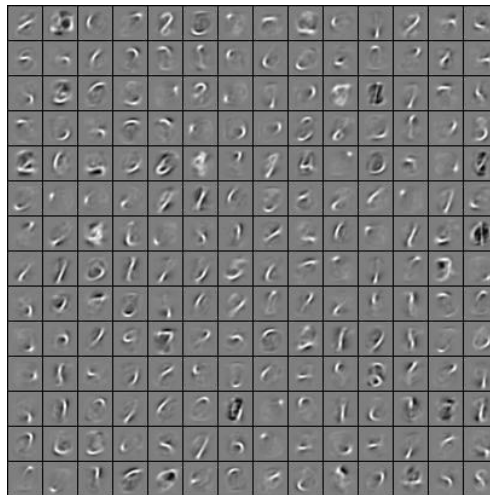
### Digits:

At iterate 0,  $f = 3.12e+02$

At iterate 400,  $f = 1.22e+01$



patches-digits.jpg



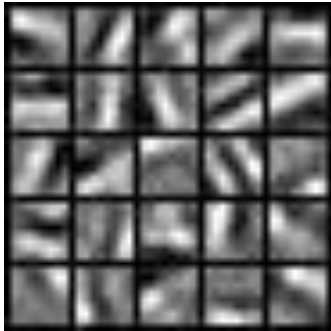
weights-digits.jpg

## Pytorch:

### Natural images:

Epoch 0: cost = 33.15

Epoch 4000: cost = 0.45

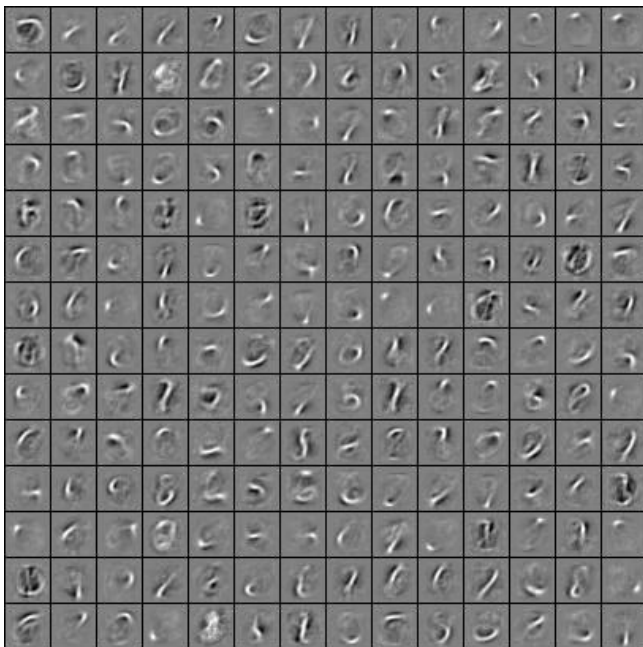


weights-natural.jpg

### Digits:

Epoch 0: cost 39.27

Epoch 100: cost 13.9



weights-digits.jpg

**PCA:**

pca\_2d:

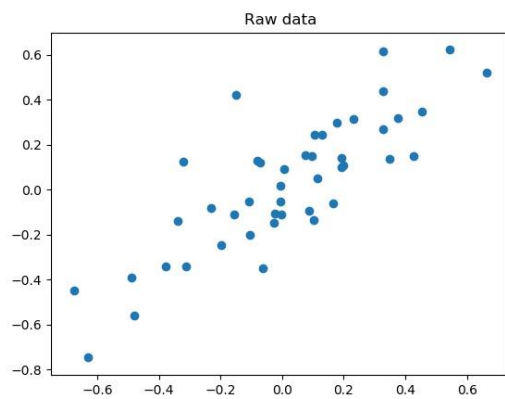


figure1.jpg

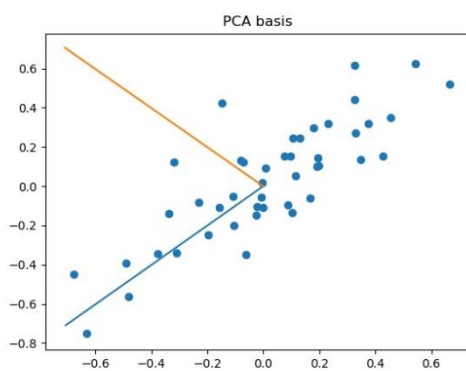


figure2.jpg

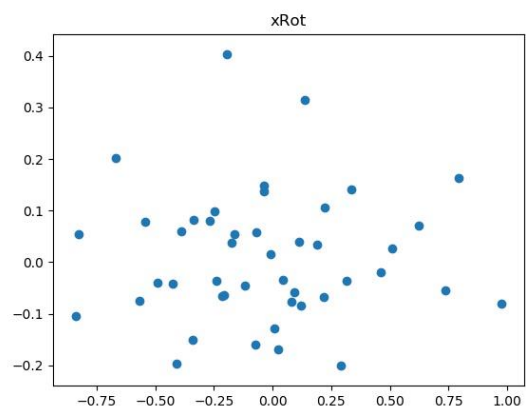


figure3.jpg

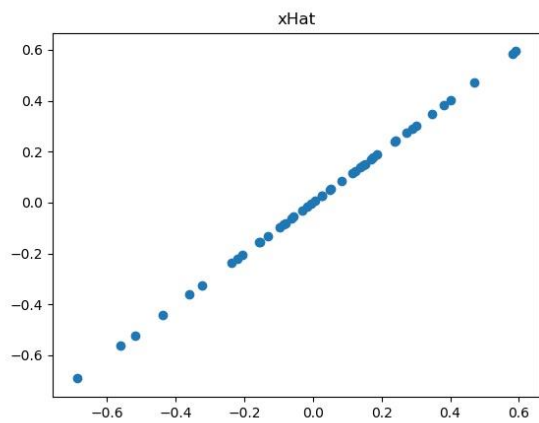


figure4.jpg

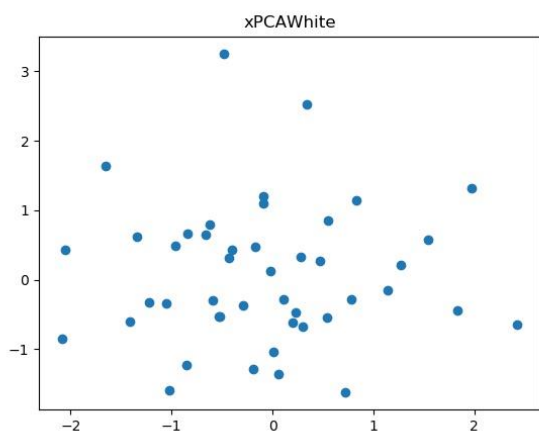


figure5.jpg

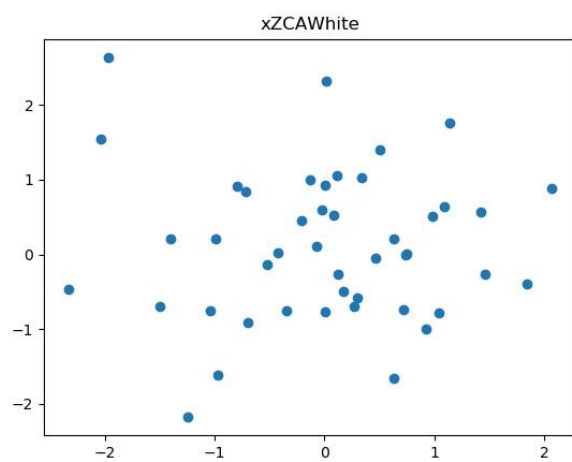


figure6.jpg

pca\_image:

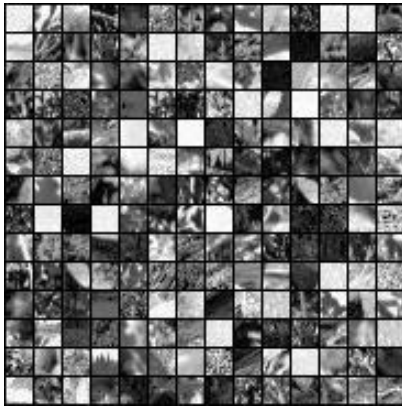


figure7.jpg



figure8.jpg

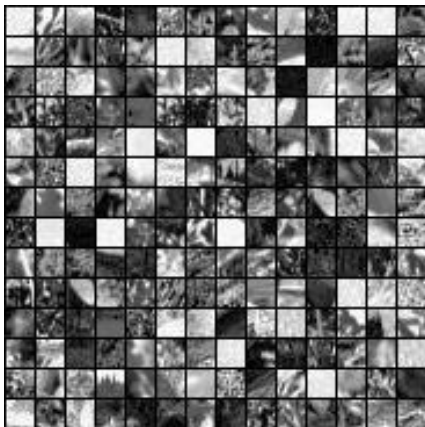


figure9.jpg

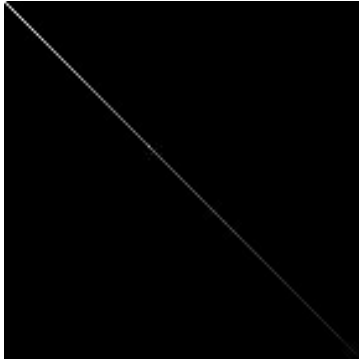


figure10.jpg

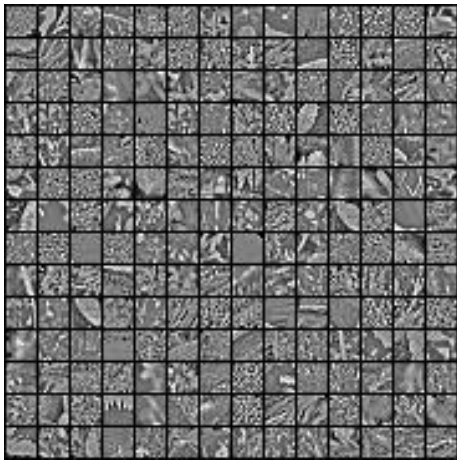


figure11.jpg

Number of principal components  $k = 116$ .