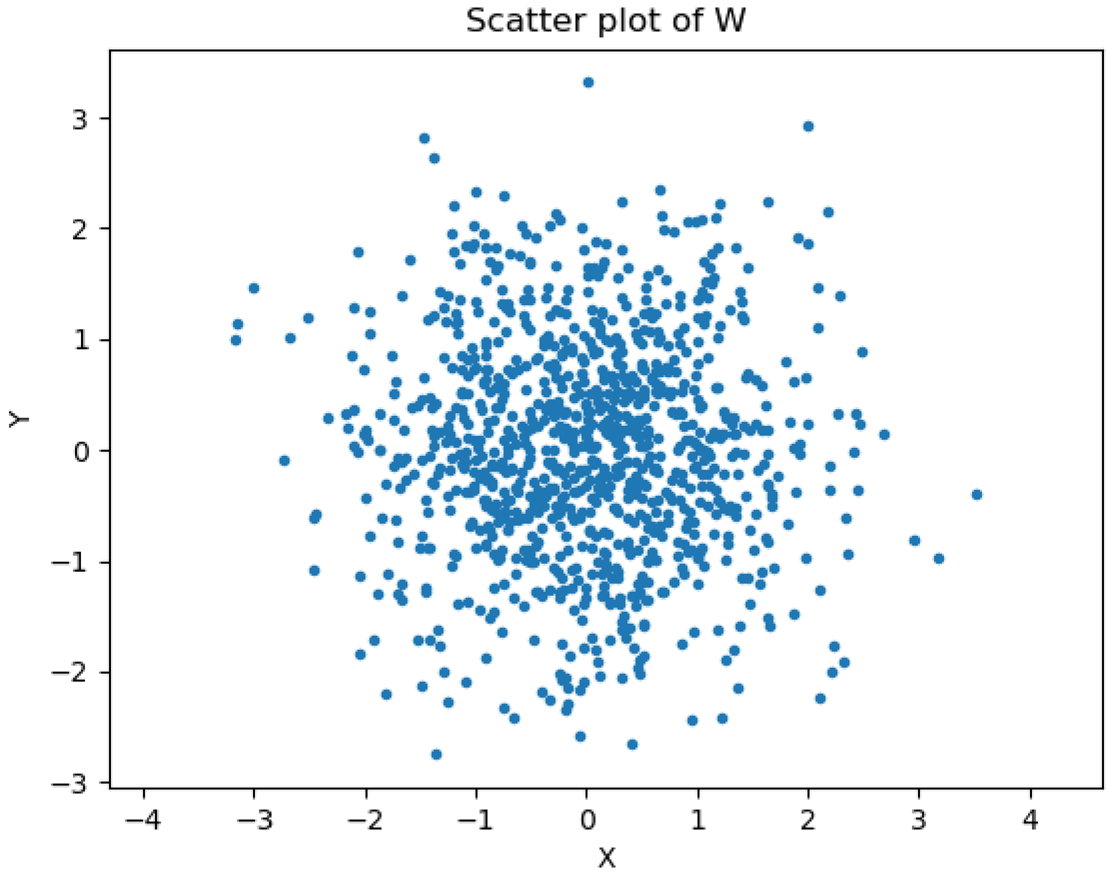
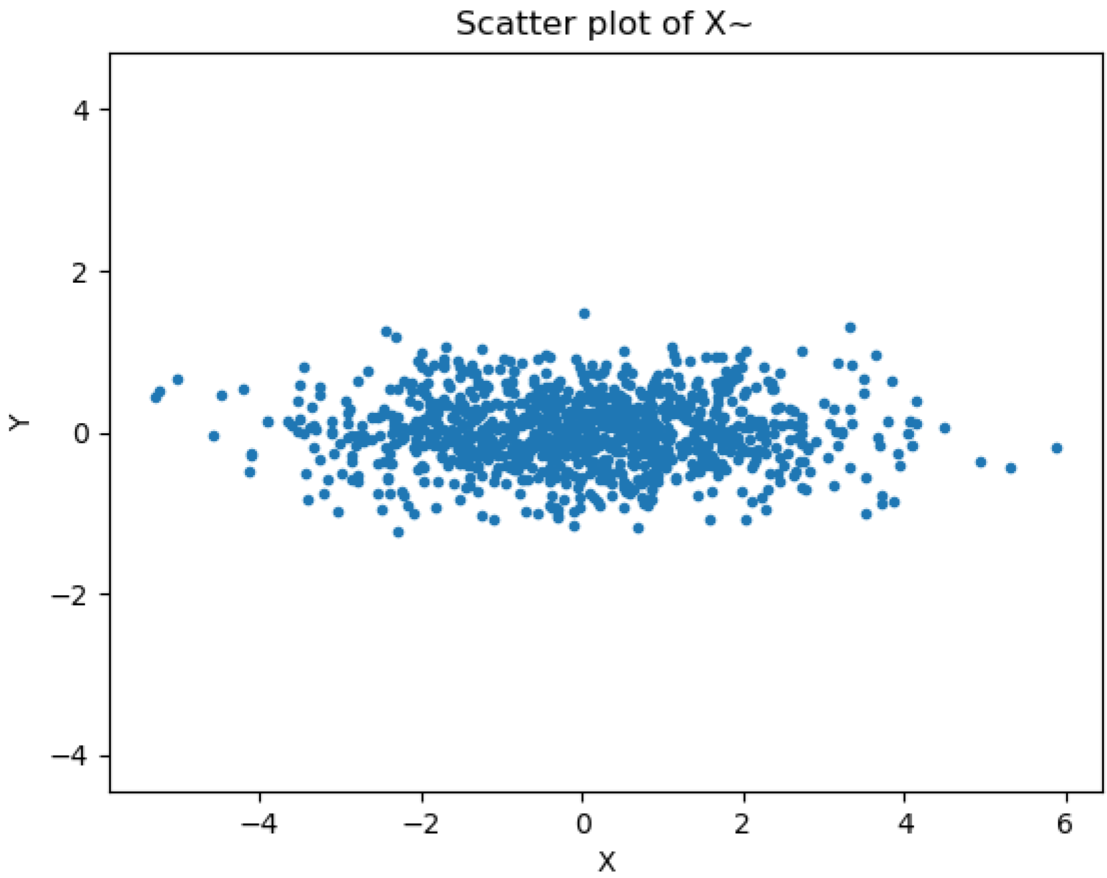
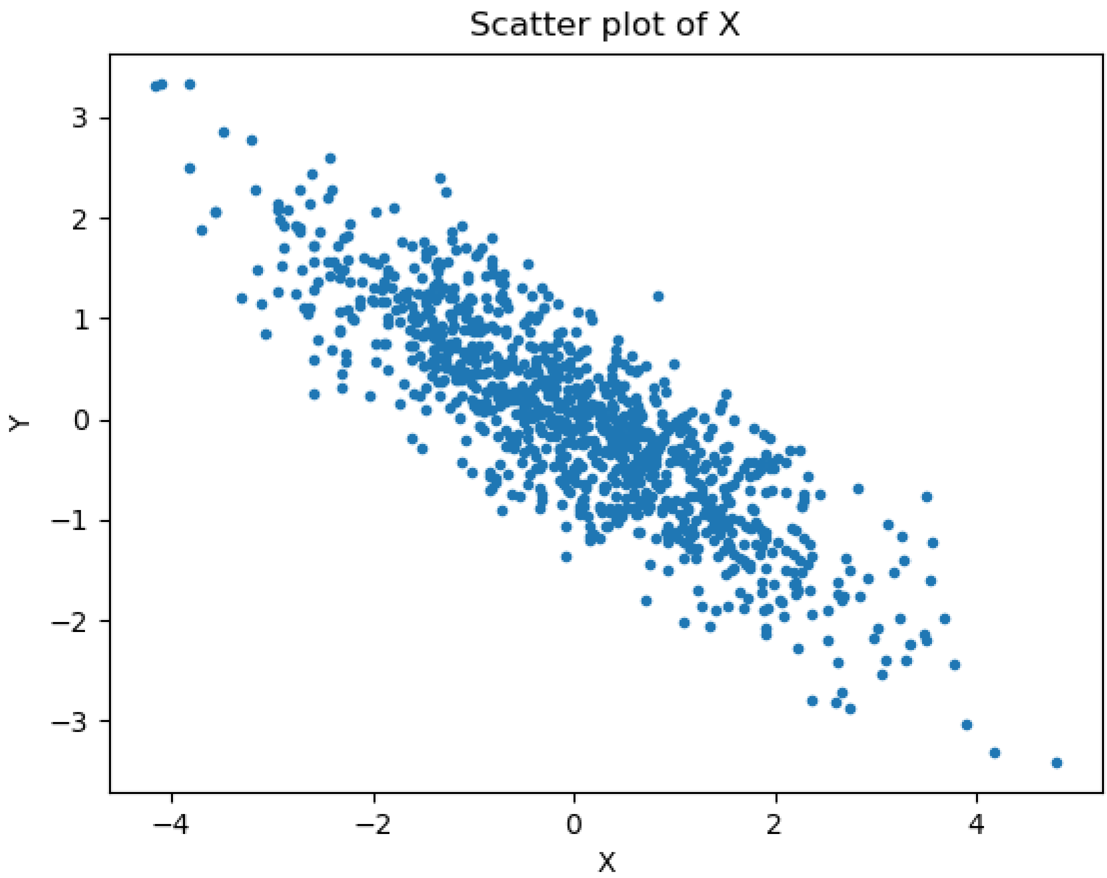
Eigen Image Analysis

Generating Gaussian random vectors







Covariance Estimation and Whitening

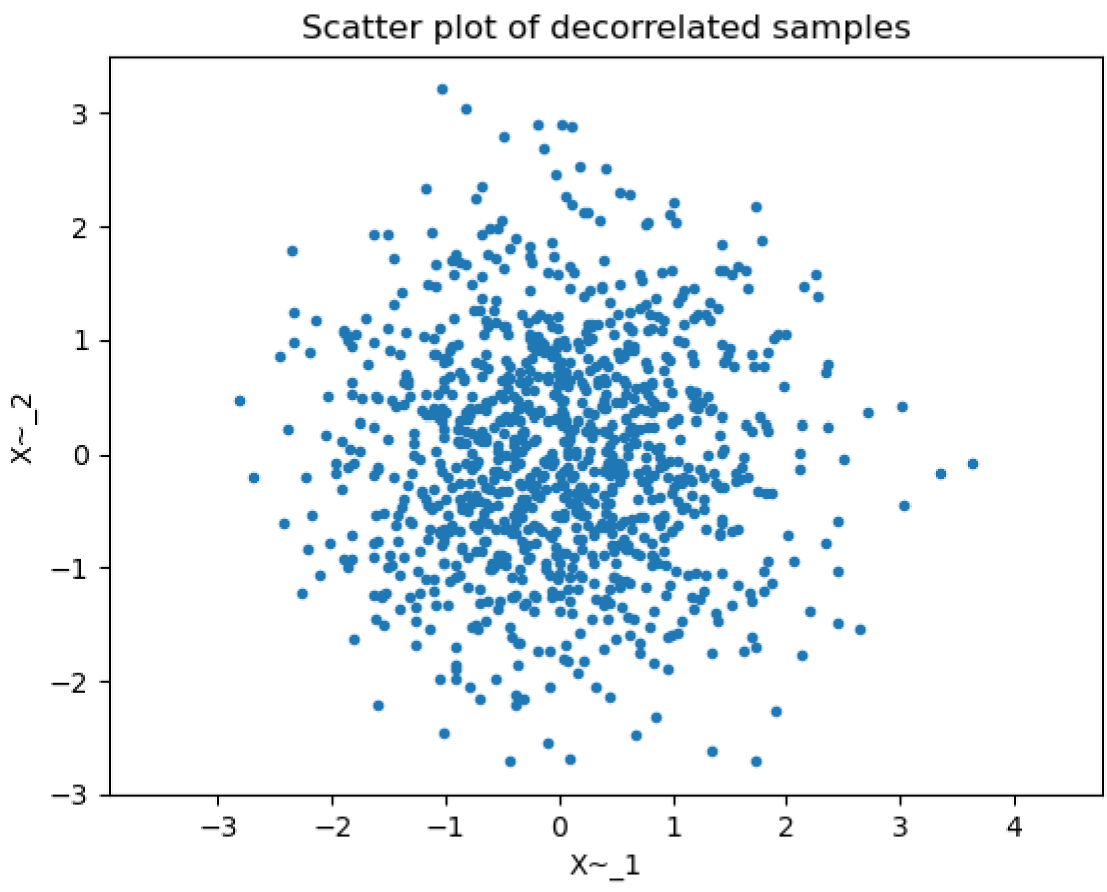
Theoretical Covariance

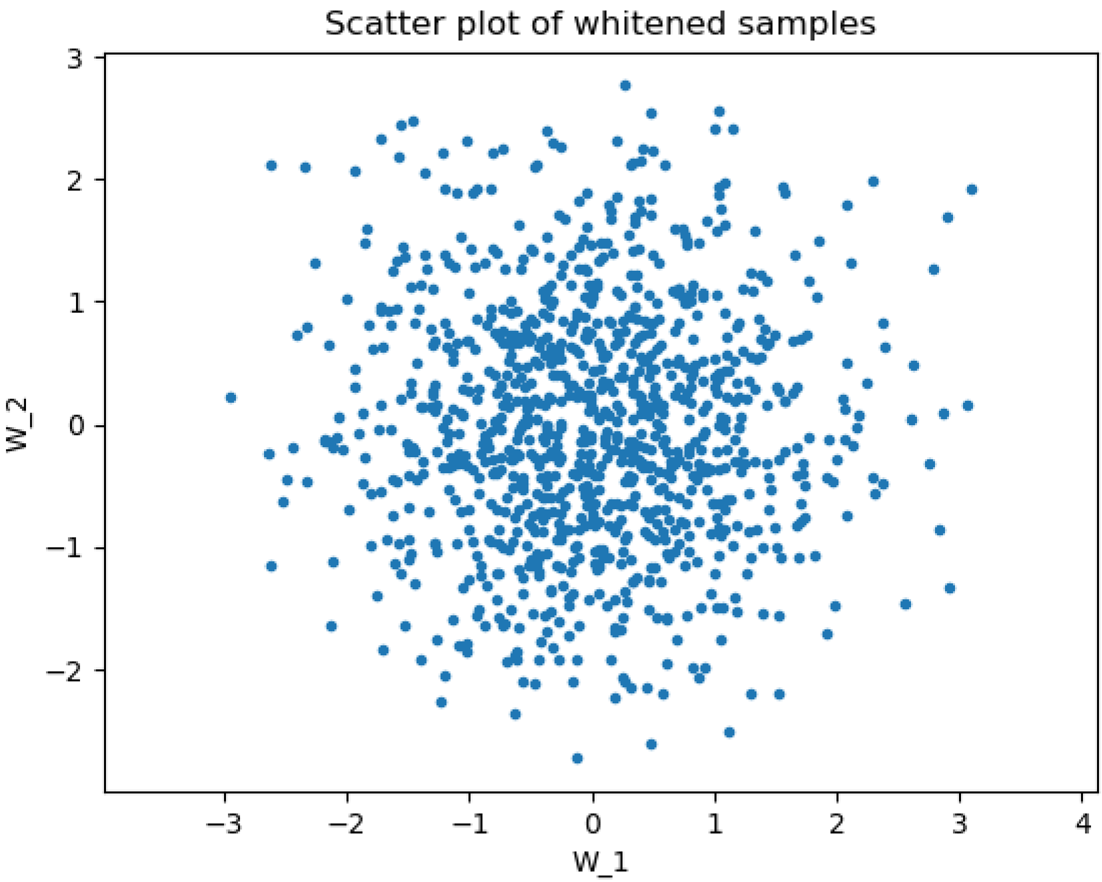
```
RX = [[2, -1.2],
      [-1.2, 1]]
```

Estimated Covariance

```
R_hat = [[ 1.97972664 -1.16673842]
         [-1.16673842  0.94524608]]
```

Scatter Plots for X_tilde_i and W_i

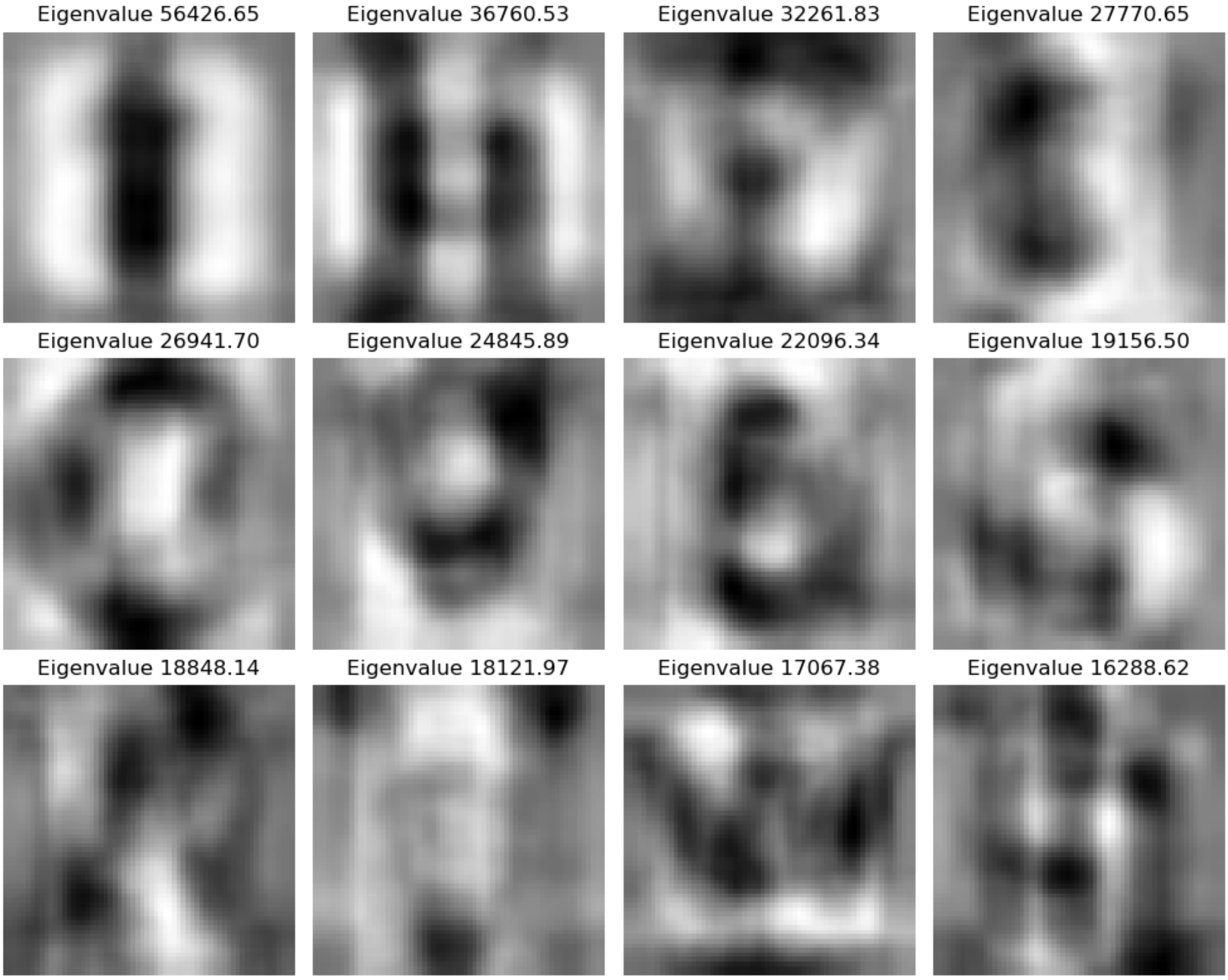


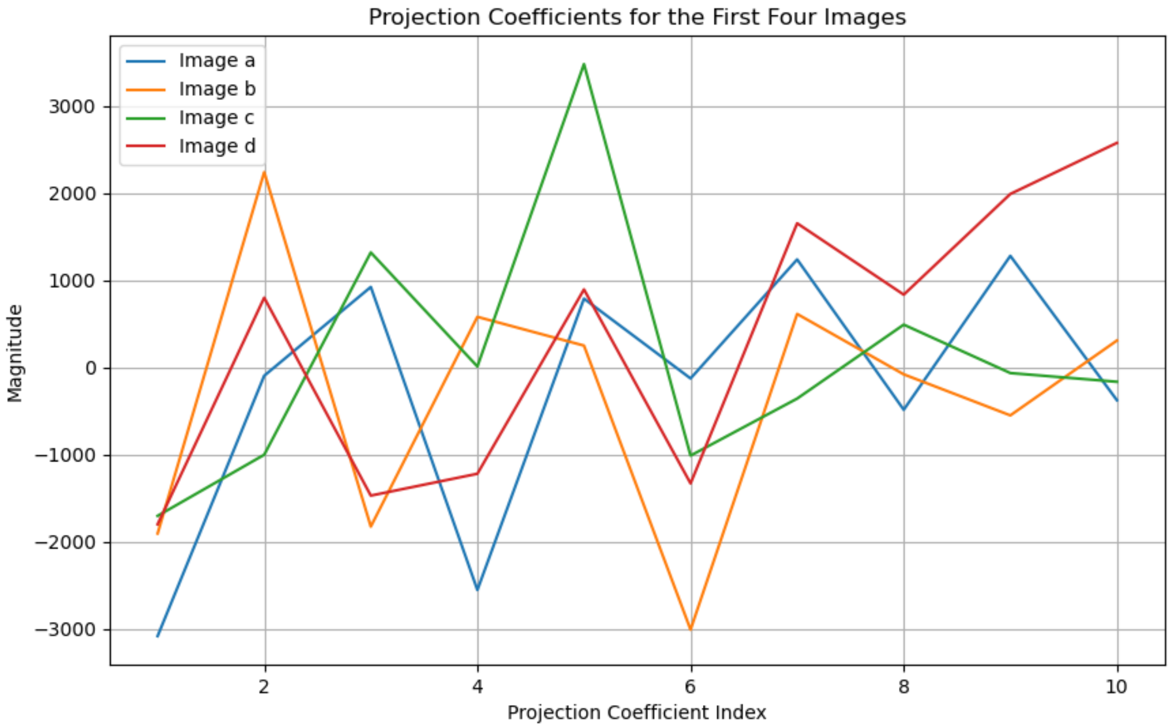


Covariance estimation R_hat_W

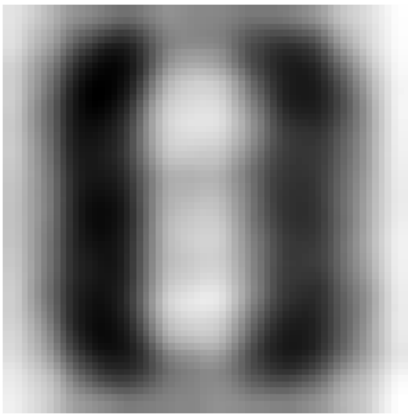
```
R_hat_whitened =
    [[ 1.00000000e+00 -1.70700958e-16]
    [-1.70700958e-16  1.00000000e+00]]
```

Eigenimages, PCA, and Data Reduction

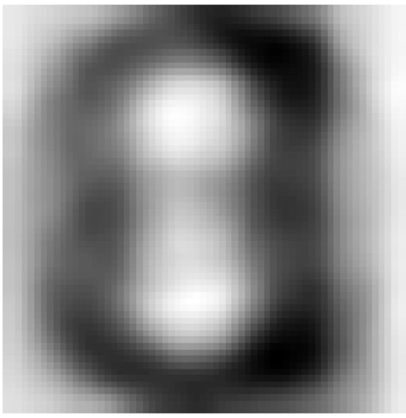

Eigenvalue 56426.65
Eigenvalue 36760.53
Eigenvalue 32261.83
Eigenvalue 27770.65
Eigenvalue 26941.70
Eigenvalue 24845.89
Eigenvalue 22096.34
Eigenvalue 19156.50
Eigenvalue 18848.14
Eigenvalue 18121.97
Eigenvalue 17067.38
Eigenvalue 16288.62


Projection Coefficients for the First Four Images
Image a
Image b
Image c
Image d
3000
2000
1000
0
−1000
−2000
−3000
Magnitude
2
4
6
8
10
Projection Coefficient Index

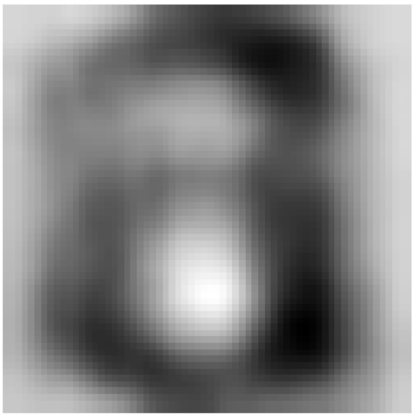
Synthesized Image (m = 1)



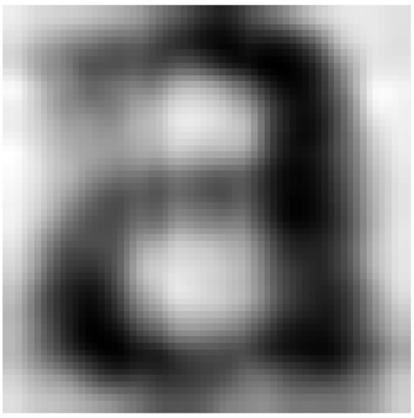
Synthesized Image (m = 5)



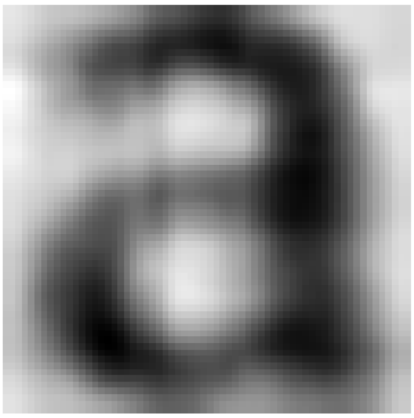
Synthesized Image (m = 10)



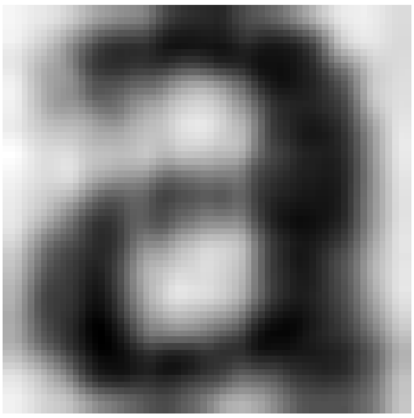
Synthesized Image (m = 15)



Synthesized Image (m = 20)



Synthesized Image (m = 30)



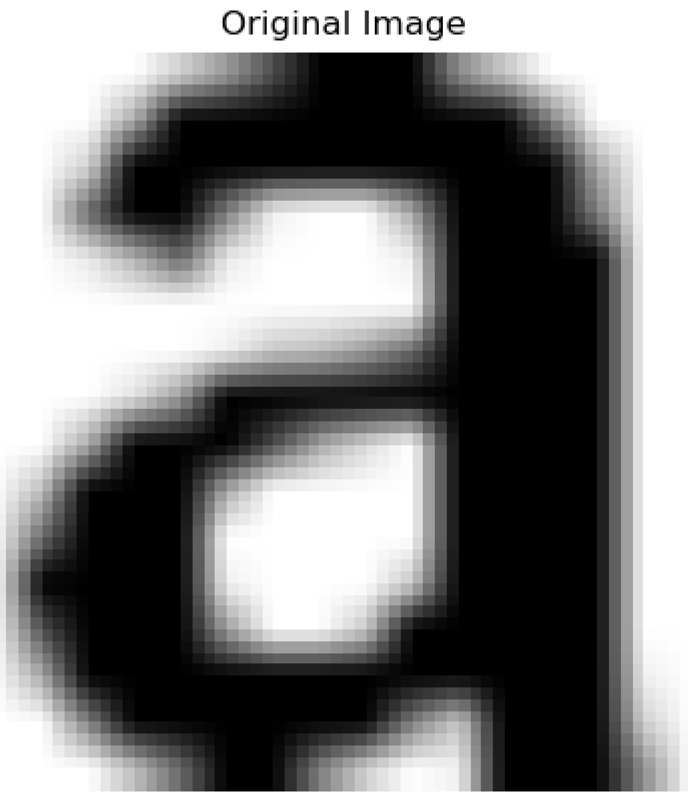


Image Classification

Misclassification using Rk

Input Character	Classifier Output
d	a
j	y
l	i
n	v
q	a
u	a
y	v

Misclassification of Bk variations

Bk = lambda_k

Input Character	Classifier Output
i	l

Input Character	Classifier Output
y	v

Bk = Rwc

Input Character	Classifier Output
g	q
y	v

Bk = Diagonal of Rwc

Input Character	Classifier Output
f	t
y	v

Bk = I

Input Character	Classifier Output
f	t
g	q
y	v

Tradeoff of data model accuracy vs estimate accuracy

The more complex the covariance model, the better it may fit the training data. But this may also lead to overfitting and poor generalization for unseen data. Simplifying the covariance model can reduce variance, but may introduce bias. The trade-off invovles finding the right balance between model complexity and available data, aiming to achieve a model that captures the data distribution while remaining general to unseen data.