ECE 637 Digital Image Processing Laboratory: Eigen-decompostion of Images

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1 Introduction

Nothing due for report.

2 Multivariate Gaussian Distributions and Whitening

2.1 Generating Gaussian Random Vectors

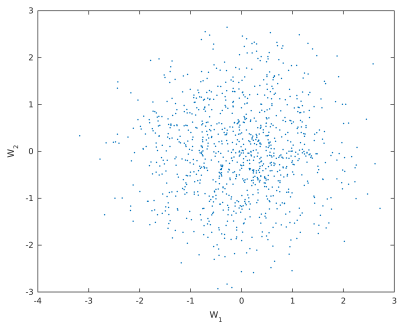


Figure 1: Scatter plot for W

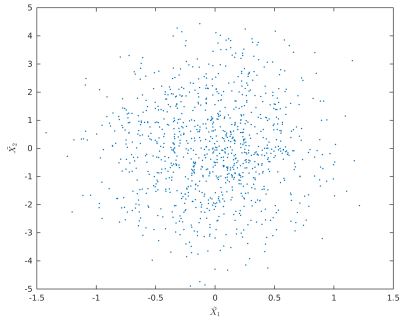


Figure 2: Scatter plot for $\tilde{X}$

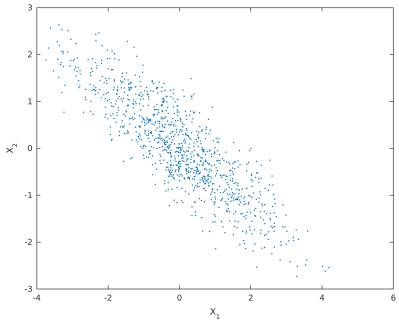


Figure 3: Scatter plot for X

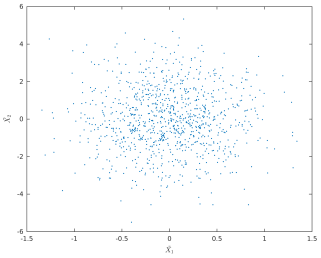
2.2 Covariance Estimation and Whitening

2.2.1 Theoretical Value of R_x

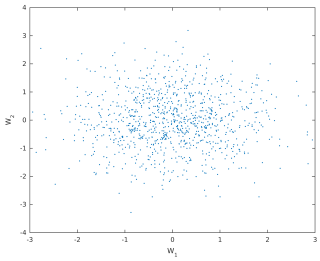
$$R_x = \begin{bmatrix} 2 & -1.2 \\ -1.2 & 1 \end{bmatrix}$$

2.2.2 Estimated Value of $\hat{R_x}$

$$\hat{R_x} = \begin{bmatrix} 2.0383 & -1.2230 \\ -1.2230 & 1.0133 \end{bmatrix}$$



(a) Scatter plot for $\tilde{X}_i$



(b) Scatter plot for W_i

2.2.3 Scatter Plots for $\tilde{X}_i$ and W_i

2.2.4 Estimated Covariance of Whitened Process

$$\hat{R_W} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

3 Estimation of Eigenvectors and Eigenvalues Using the Signular Value Decomposition

Nothing due for report.

4 Eigenimages, PCA and Data Reduction

4.1 12 Eigenvalues

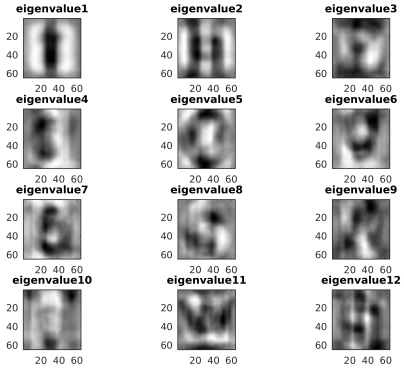


Figure 5: 12 Eigenimages

4.2 Projection Coefficients vs. Eigenvector Number

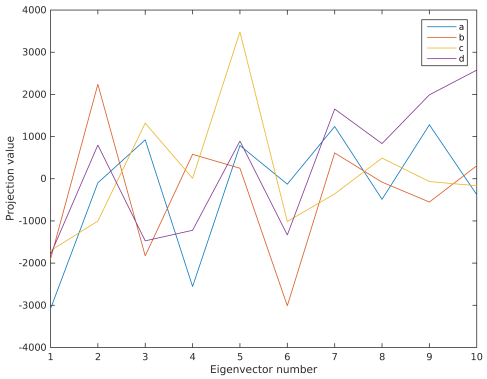


Figure 6: Projection Coefficients vs. Eigenvector Number

4.3 Original Image and the 6 Resynthesized Images

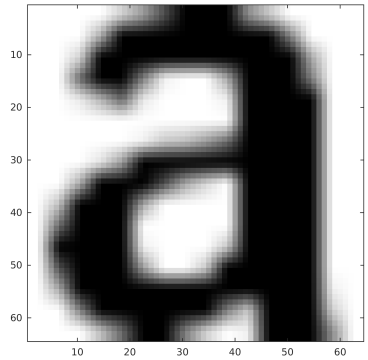


Figure 7: The Original Image of "a"

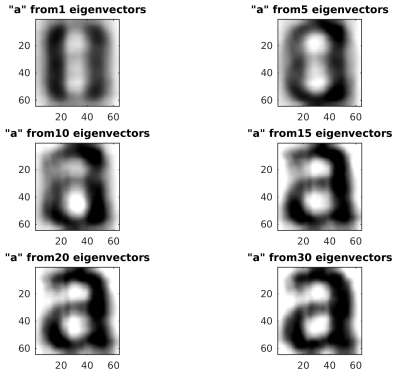


Figure 8: Synthesized Versions of of "a"

5 Image Classification

5.1 Classification and PCA

5.1.1 Classification errors using Eigenvectors

Acutual Letter	Mis-classified Letter
d	a
j	y
l	i
n	v
p	e
q	a
u	a
y	v

5.1.2 Classification errors using $B_k = \Lambda_k$

Acutual Letter	Mis-classified Letter
i	l
y	v

5.1.3 Classification errors using $B_k = R_{wc}$

Acutual Letter	Mis-classified Letter
g	q
y	v

5.1.4 Classification errors using $B_k = \Lambda$

Acutual Letter	Mis-classified Letter
f	t
y	v

5.1.5 Classification errors using $B_k = I$

Acutual Letter	Mis-classified Letter
f	t
g	q
y	v

5.2 Conclusions

1. $B_k = \Lambda_k$,$B_k = R_w c$, and $B_k = \Lambda$ have similar performance and have the smallest amount of errors.
2. There is a trade-off between the data model accuracy and estimate accuracy. More complex the model is, poorer performance of the estimation accuracy.