LECTURE 6. PCA
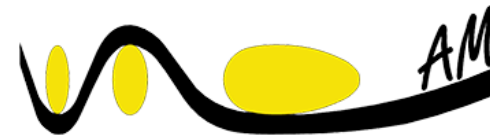
(Principal Component Analysis)

MANU 465

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The Prostate, Lung, Colorectal, and Ovarian (PLCO) Cancer Screening Trial is a large, randomized trial designed and sponsored by the National Cancer Institute (NCI) in 2006 to determine the chance of getting PLCO cancer. Participants are being followed and additional data will be collected through 2015, for 216 patients, labeled as Cancer and Healthy, with 4000 features (info related to gene, blood, etc.)

|	X_1	X_2	X_3	X_4	...	X_{4000}	Result
Person 1	0.063915364	0.025408624	0.025536250	0.012817321		0.036122788	Cancer
Person 2	0.033241734	0.051084790	0.036122788	0.029651841		0.079289645	Cancer
Person 3	0.018484138	0.056304950	0.054195240	0.079289645		0.039348744	Healthy
Person 4	0.0086176926	0.021738490	0.0097349817	0.050676957		0.039736748	Cancer
Person 5	0.035628796	0.027409980	0.027520513	0.039736744		0.039736744	Healthy
Person 6	0.037925478	0.014913797	0.052254751	0.057712860		0.0147349818	Healthy
.	...						...
Person 216	0.035628796	0.027409980	0.027520513	0.039736744		0.039736475	Cancer

PCA (Principal Component Analysis)

PCA is a powerful tool which:

- Reduces the dimension of the data.

- Takes 4 or more variables and makes a 2D plot.

- Finds the dominant combinations of variables that describes as much of the data as possible.

Objective

In this lecture, you will learn <u>what PCA does</u>, <u>how it does it</u>, and <u>how to apply it</u> to get deeper insight into your data.

What does PCA do?
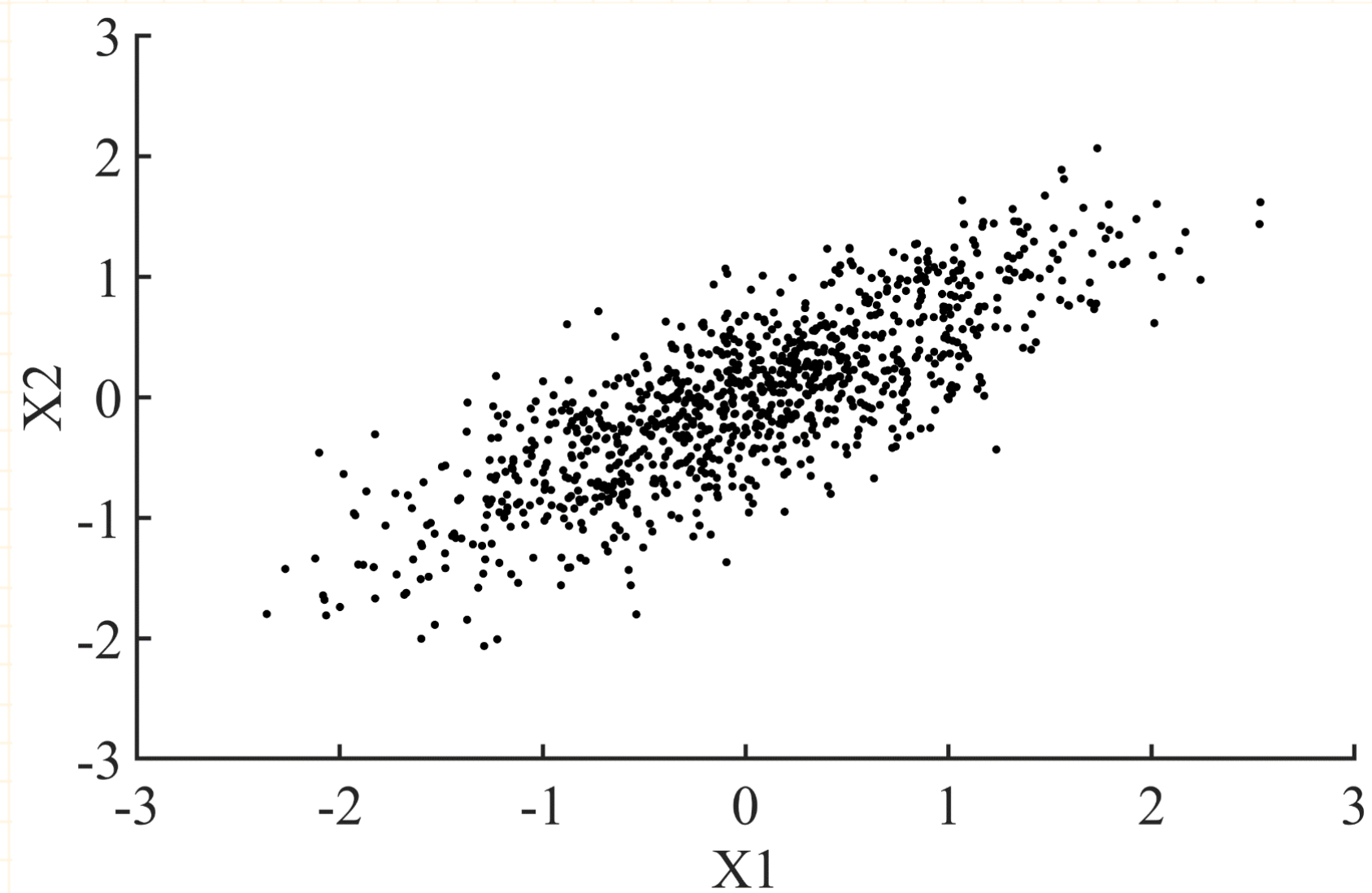
How does it work?

○ Fundamentally, PCA transform the data into directions of maximum variance.

○ Mathematically, these directions are the Eigenvectors; and the variances in each direction are the corresponding Eigenvalues of the covariance matrix of data.

Example) Find the direction of maximum variance for this dataset.

X1	X2
3.8	5.1
2	3
1.9	3.1
5	5.9
1.3	2
3	3.9
5.3	6.7
4	5
1	1.9
2.7	3.4
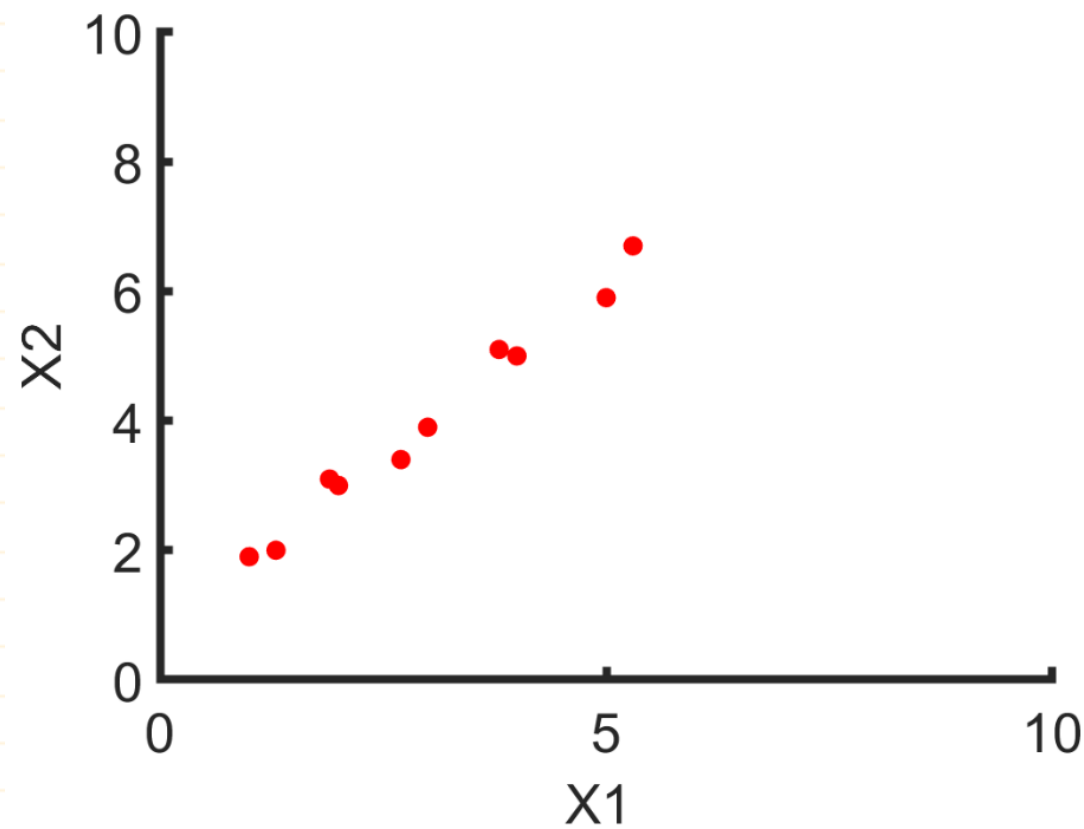
Does PCA always work?
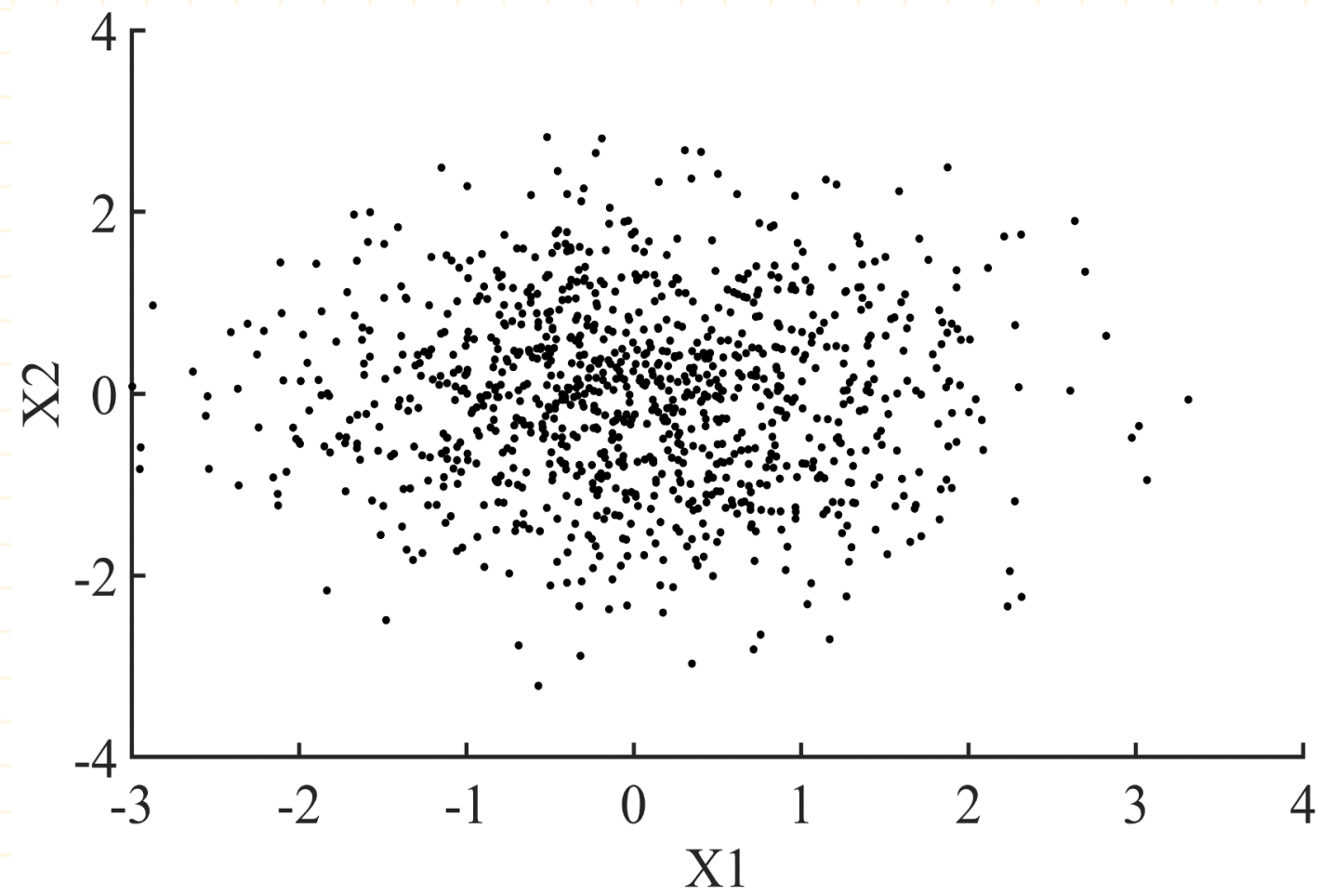
How to apply it?

1. Compute the Covariance Matrix C for X (the input data).

2. Compute the Eigenvectors (V_i) and Eigenvalues (λ_i) of C.

3. Sort the eigenvalues from the maximum to minimum ($\lambda_1 > \lambda_2 > \lambda_3 > \cdots . > \lambda_n$)

4. First Principal Component is PC1=X*V_1 , and PC2=X*V_2 , ...

5. We may just keep the first few PCs and chop of the rest (shrinking the dimension of the data).

6. Contribution of the m PCs we used to describe the data=$\dfrac{\sum_1^m \lambda_i}{\sum_1^n \lambda_i}$

In Python, SKLearn, there is a built-in Function:

```python
from sklearn.decomposition import PCA
PrinComp=PCA(n_components=2)
PrinComp.fit(X)
Z=PrinComp.transform(X)
```

Please check the code, Wood_PCA.ipynb on Canvas.

Practice:

1. *Assignment 5.*
2. *Apply this method to a set of images (for example, the Fashion or Digit MNIST).*
3. *Apply this to the Semi-Conductor dataset.*
4. *Attend Tutorial 5.*

Summary

- PCA is a linear transformation which find the direction of maximum variance in the data.

- It reduces the dimension of the data without loosing much information.

- It is a good tool for data visualization.

- In practice, we can simply, use the PCA built-in function in Python to apply PCA to a dataset.