

Statistics and Data Analysis

Unit 05 – Lecture 03: Principal Component Analysis (PCA)

Tofik Ali

School of Computer Science, UPES Dehradun

February 17, 2026

<https://github.com/tali7c/Statistics-and-Data-Analysis>

Quick Links

Overview

PCA Intuition

Explained Variance

Exercises

Demo

Summary

Agenda

- 1 Overview
- 2 PCA Intuition
- 3 Explained Variance
- 4 Exercises
- 5 Demo
- 6 Summary

Learning Outcomes

- Explain PCA as a variance-maximizing linear projection

Learning Outcomes

- Explain PCA as a variance-maximizing linear projection
- State why scaling is important before PCA

Learning Outcomes

- Explain PCA as a variance-maximizing linear projection
- State why scaling is important before PCA
- Interpret explained variance ratio and scree plot

Learning Outcomes

- Explain PCA as a variance-maximizing linear projection
- State why scaling is important before PCA
- Interpret explained variance ratio and scree plot
- Use PCA for visualization and noise reduction

PCA Intuition: Key Points

- Find new axes (components) capturing maximum variance

PCA Intuition: Key Points

- Find new axes (components) capturing maximum variance
- Components are orthogonal

PCA Intuition: Key Points

- Find new axes (components) capturing maximum variance
- Components are orthogonal
- PC1 captures most variance

Explained Variance: Key Points

- Explained variance ratio per component

Explained Variance: Key Points

- Explained variance ratio per component
- Choose k via scree plot / cumulative variance target

Explained Variance: Key Points

- Explained variance ratio per component
- Choose k via scree plot / cumulative variance target
- Validate downstream performance

Exercise 1: Scaling

Why scale features before PCA?

Solution 1

- To prevent large-unit features dominating variance.

Exercise 2: Components

Are PCA components original features?

Solution 2

- No; they are linear combinations.

Exercise 3: Choosing k

If first 2 PCs explain 88% and you need 90%, what do you do?

Solution 3

- Add next PC(s) until target reached.

Mini Demo (Python)

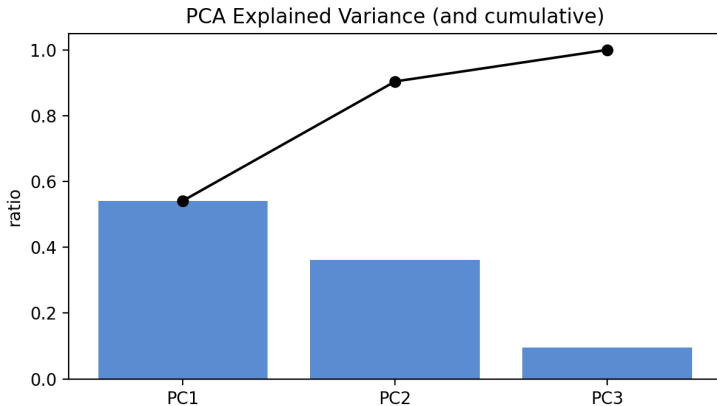
Run from the lecture folder:

```
python demo/demo.py
```

Outputs:

- images/demo.png
- data/results.txt

Demo Output (Example)



Summary

- Key definitions and the main formula.

Summary

- Key definitions and the main formula.
- How to interpret results in context.

Summary

- Key definitions and the main formula.
- How to interpret results in context.
- How the demo connects to the theory.

Exit Question

Why might PCA improve a model even though it discards some variance?