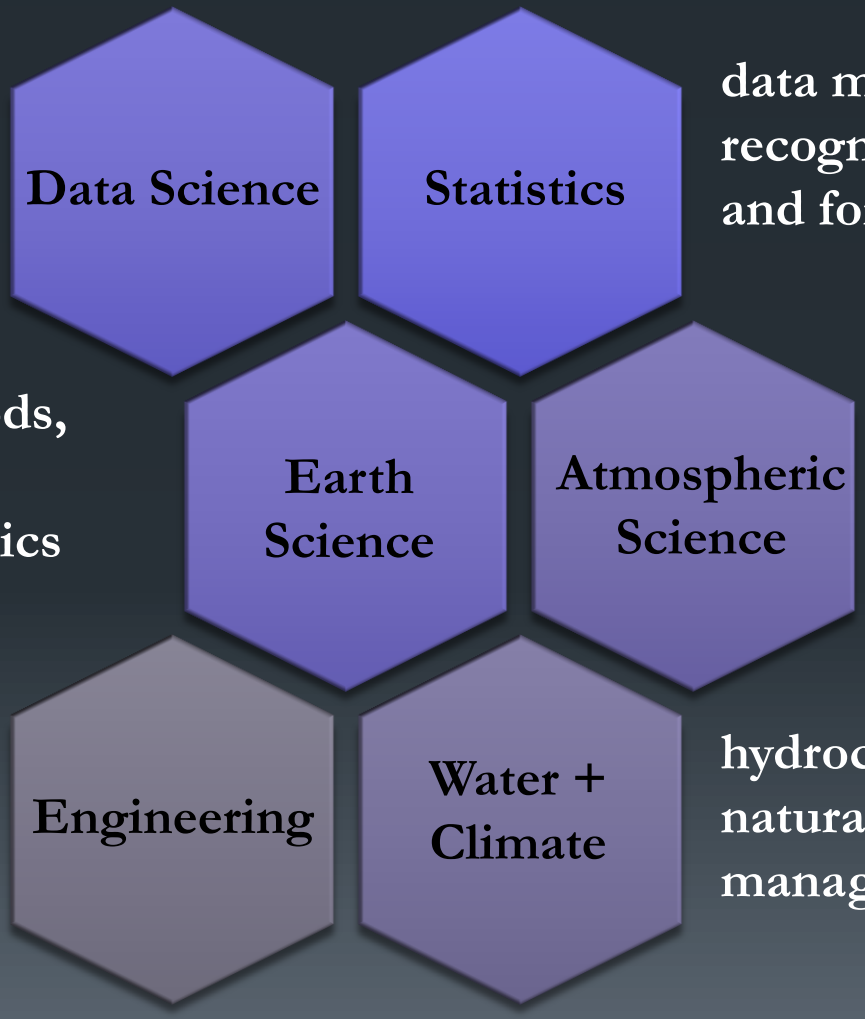
MULTIVARIATE STATISTICAL INFERENCE

Menggian LU

WHO AM I?



data mining, pattern recognition, prediction and forecasts

severe weather (floods, tornado etc.), atmospheric dynamics

hydroclimatology, natural resources management, policy

WHO ARE YOU?

What do you already know?
What is your expectation?

Survey

http://goo.gl/forms/0qy64czEQ9

SOME ADMINISTRATIVE BITS

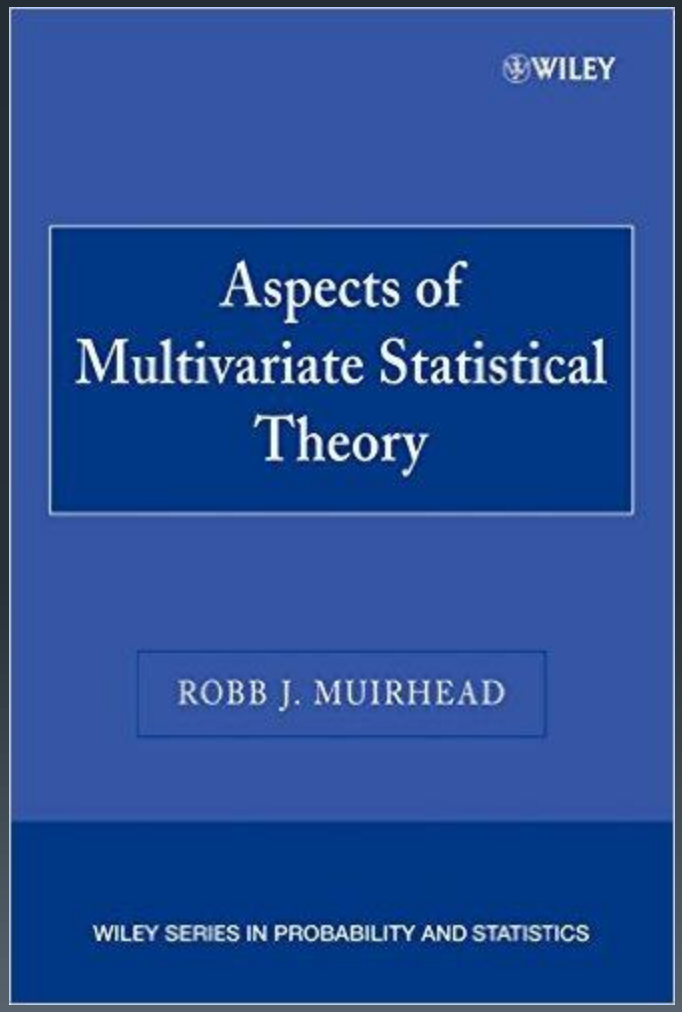
COURSEWORKS@COLUMBIA
Piazza@COURSEWORKS
*GITHUB (https://github.com/**MRandomMax**)*

Office Hours: Friday 10AM – 11AM

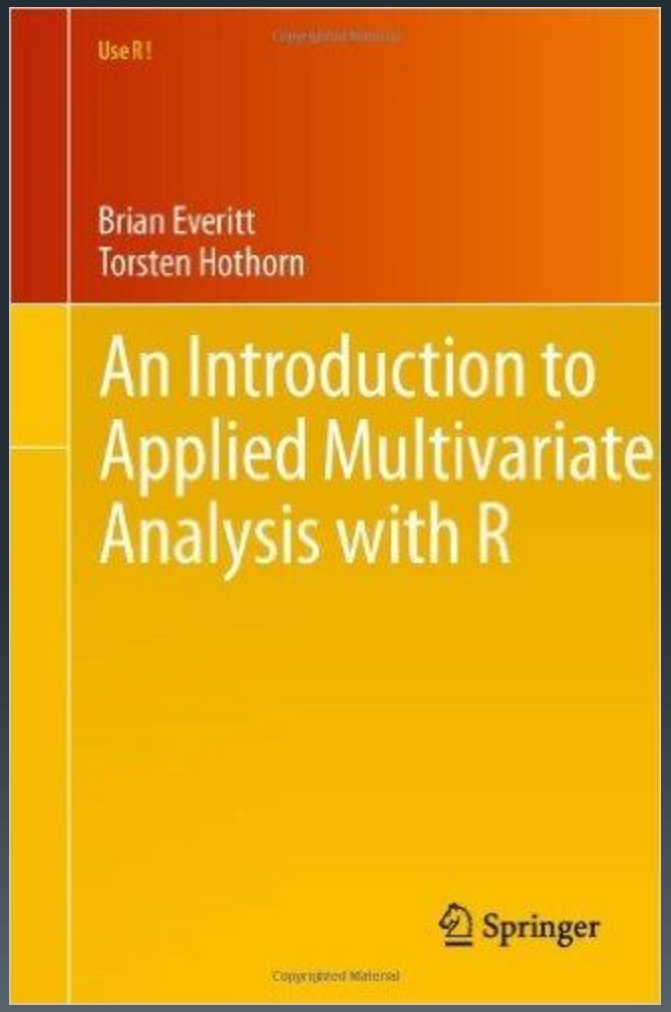
TA: Haolei WENG
TA Office Hours: TBA

BOOKS

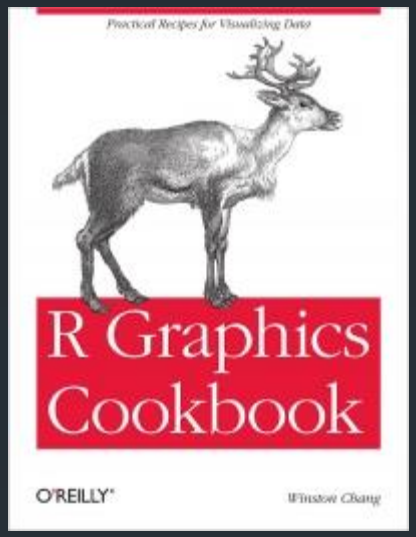
AMST

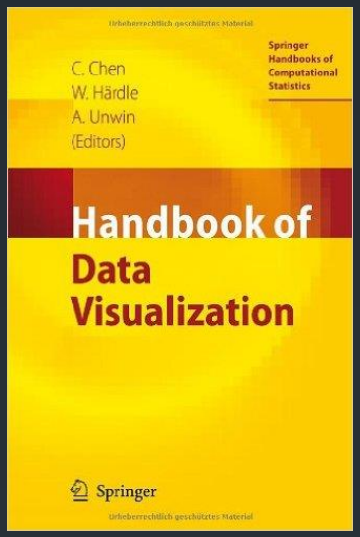


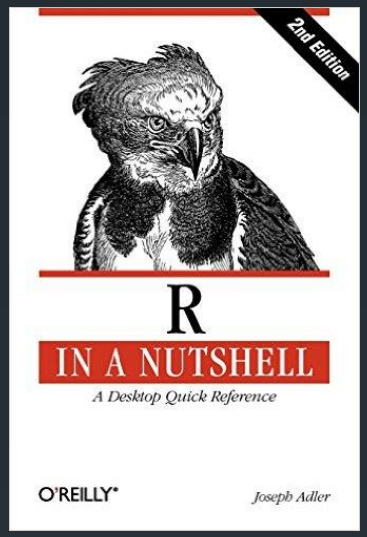
IAMA



MORE TEXTS & WEBSITES ON R







Quick-R: http://www.statmethods.net/
R-bloggers: http://www.r-bloggers.com/
Github: http://github.com/

WORD CLOUD

Time-lagged spatial structure

Hierarchical clustering

Patterns recognition

Signal detection

Cluster analysis

Partitional clustering

Spatiotemporal

Exploratory factor analysis

Principal component analysis

MSI

Canonical correlation analysis

Dimension reduction

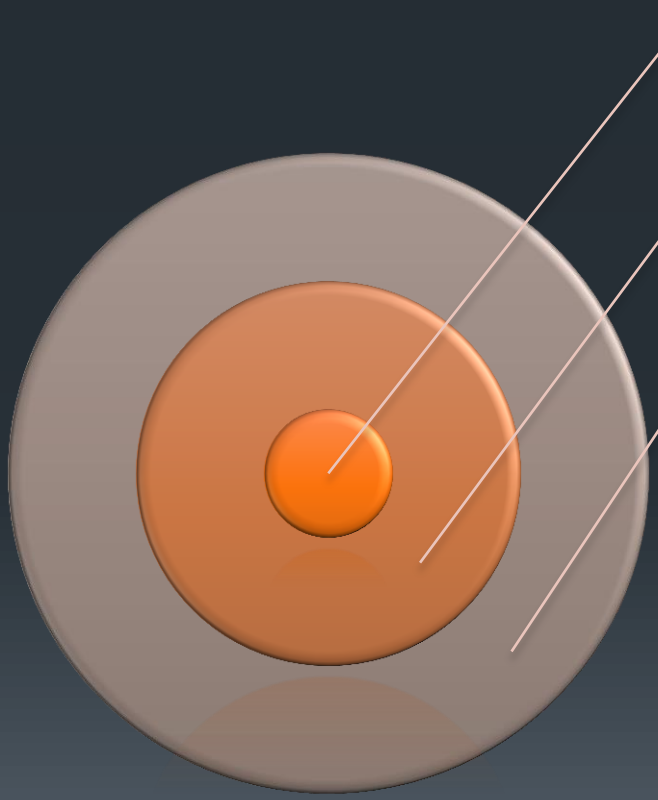
Correlation networks

Confirmatory factor analysis

Multidimensional scaling

Independent Component Analysis

THE PLAN



- Fundamentals

- R practical section
- Assignments (real data)

- Themes & topics
- Practical section
- Theory & Techniques

EVERY STEP COUNTS…

- Practice interactively and collaboratively
- No matter what is your level of coding, analysis or modeling, DO participate in all the coding – the fast way to learn
- *The earlier you fail, the faster you grow*

ASK FOR HELP

THE EVALUATION

Course Evaluation:	
Participation:	10%
Assignment:	30%
Midterm:	25%
Final Exam:	35%

Why Multivariate Approach?

The World is Multivariate

- Data Scientists or Researchers now are dealing with many variables of interest, and it's getting more and more complex
- The space defined by all/most/some variables matter

THE ESSENCE…

- To recognize the inherent structure of "the space" through application and interpretation of a variety of statistical methods

Why Multivariate Approach?

- Observations: Univariate → "The Space"
- Multiple response outcomes
  - *The target: Univariate → A Space*

But, sometimes no outcome variable(s)

THE PURPOSES…

Detect & Explore

- Determine structure
- Extract information e.g. The Survey
- Correlational

EDAV

Explain & Predict

- Causality
- Target outcomes e.g. your weather prediction

THE PURPOSES…

Prediction & Explanation

- The goal in most research is to predict
- Then what are the best predictors?
  - e.g. Extract from "the Space" by Principal component analysis
- However, determining variable importance can be a suspect endeavor
  - Deemed statistically significant may not have a physical meaning, nor be reproducible
  - Also has to do with the sample

THE PURPOSES…

Detect & Explore

- Another goal is to find the underlying structure, latent variable
  - e.g. Observed behaviors like Giddiness, Silliness, Irrationality, Possessiveness and Misunderstanding reduced to the underlying construct of 'Love'

- Typical approaches involve dimension reduction (PCA, MDS), classification (cluster analysis) and reducing variables (factor analysis)

Initial examination of data is important

Checklist:

1. Types of variables: nominal/categorical, ordinal, continuous (interval or ratio)
2. Missing values (complete-case analysis or available-case analysis) or outliers (transformation, log or √)

@IAMA1.3
Read IAMA Ch1

Initial examination of data is important

Checklist:

1. Types of variables: nominal/categorical, ordinal, continuous (interval or ratio)
2. Missing values (complete-case analysis or available-case analysis) or outliers (transformation, log or √)
3. Sample vs. Population
   - Generalize to real world from sample – the purpose of inferential analyses
   - Avoid sample-specific result!

Multivariate Distributions

- Describe the underlying structure of a vector of random variables
- Derive marginal properties of the individual variable
- Describe relationships between variables
- Inference based on a sample

A QUICK REVIEW

Let x_{ij} be j^{th} variable (j=1,…,p) on the i^{th} observation

***X** is the n × p matrix:*

$$X = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1j} & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2p} \\ \vdots & \vdots & & \vdots & & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{ip} \\ \vdots & \vdots & & \vdots & & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nj} & \cdots & x_p \end{pmatrix}$$

Univariate Statistics:

Sample mean: $\overline{x}_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij} \qquad j = 1, \ldots, p$

Sample variance: $s_j^2 = \frac{1}{n-1}\sum_{i=1}^{n} \left(x_{ij} - \overline{x}_j\right)^2 \qquad j = 1, \ldots, p$

Bivariate Statistics:

Sample covariance:

$$s_{jk} = \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{ij}-\overline{x}_j\right)\left(x_{ik}-\overline{x}_k\right) \qquad j=1,\ldots,p;\ k=1,\ldots,p$$

$$s_j^2 = s_{jj}$$

Sample correlation coefficient:

$$r_{jk} = \frac{s_{jk}}{\sqrt{s_{jj}}\sqrt{s_{kk}}} \qquad j=1,\ldots,p;\ k=1,\ldots,p$$

Properties of the Correlation Coefficient

… If $|r_{jk}| = 1$ *, there is constants (a,b) that* $x_{ij} = a + bx_{ik}$

… the value of r_{jk} *does not change w/ linear transformation of variable*

AFTER CLASS

1. Complete the survey
2. Install R and Rstudio
3. Read AMST Ch1 and IAMA Ch1, Syllabus