Methodological Foundations of Biomedical Informatics Fall 2015 (BMSC-GA 4449)

Course Directors:
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Course Overview

This course provides an overview of foundational knowledge and essential methods relevant for all areas of biomedical informatics. Students will explore recurring themes and application domains most frequently used in the field. The course will be technical and rigorous, and it will include a number of computer science topics. The course content has been selected by the curriculum committee, and the topics will change over time. The majority of the coursework will be programming assignments and readings.

Learning objectives

The student will learn and understand the most commonly used methodologies in the field of biomedical informatics.

Programming Languages

Learning the following programming languages during the duration of the course is required:

- **Python** - Learning Python 5, *Think Python, Python for Data Analysis, SciPy, How to Think Like a Computer Scientist: Learning with Python, Learn Python the Hard Way*
- **R** - Learning R
- **MATLAB** - MATLAB: A Practical Introduction to Programming and Problem Solving 2nd Edition by Stormy Attaway
- **JavaScript, JQuery, D3**:

Course Assessment

- Programming Assignments (40%).
- Discussions (25%)
- Final Project (35%)

Lectures

**Lecture 1** Introduction (September 1, 2015 TRB 718 5pm)
Lecturer: Ruggles & Fenyo
Lecture 2  Scientific Programming (September 8, 2015 TRB 718 5pm)
Lecturer: Peskin

Reading List

• Linux/HPC
• Git

Lecture 3  Algorithms (September 15, 2015 TRB 718 5pm)
Lecturer: Peskin

Reading List

• The Algorithm Design Manual by Steven S Skiena, Chapters 1-4
• Visualgo

Additional Reading

• Rosalind, Algorithm Heights
• Coursera: Algorithms Part I
• Coursera: Algorithms Part II

Lecture 4  Data visualization (September 22, 2015 TRB 718 5pm)
Lecturer: Ruggles

Reading List

• Data visualization: A view of every Points of View column
• Data Analysis with Open Source Tools by Philipp K. Janert

Additional Reading

• Visualize This: The FlowingData Guide to Design, Visualization, and Statistics by Nathan Yau

Lecture 5  Statistics (September 29, 2015 TRB 718 5pm)
Lecturer: Fenyo

Reading List
- All of Statistics by Larry Wasserman, Chapters 1-3
- Let's Give Statistics the Attention it Deserves
- Statistics for Biologists

Additional Reading

- Think Stats by Allen B. Downey
- Think Bayes by Allen B. Downey
- An Introduction to Statistical Modeling of Extreme Values by Stuart Coles
- All of Nonparametric statistics by Larry Wasserman

Lecture 6 Linear Algebra (October 6, 2015 TRB 718 5pm)
Lecturer: Fenyo

Reading List

- Quick Review of Matrix and Real Linear Algebra by KC Border

Additional Reading

- Coursera: Coding the Matrix

Lecture 7 Optimization (October 13, 2015 TRB 718 5pm)
Lecturer: Fenyo

Reading List

- An Introduction to Optimization Chapters 6-9, 19, 20

Additional Reading

- Coursera: Linear and Discrete Optimization

Lecture 8 Machine Learning (October 20, 2015 TRB 718 5pm)
Lecturer: Aphinyanaphongs

Reading List

- An Introduction to Statistical Learning by Gareth James et al. Chapter 1-2
- ROC Graphs: Notes and Practical Considerations for Researchers by Tom Fawcett

Additional Reading

- Coursera: Machine Learning
• A Gentle Introduction to Support Vector Machines in Biomedicine: Theory and Methods (Volume 1) by Alexander Statnikov et al.

• A Gentle Introduction to Support Vector Machines in Biomedicine: Case Studies and Benchmarks (Volume 2) by Alexander Statnikov et al.

Lecture 9 Information Retrieval (October 27, 2015 TRB 718 5pm)
Lecturer: Aphinyanaphongs

Reading List

• Information Retrieval by William Hersh Chapter 1-2

Lecture 10 Experimental design (November 3, 2014 TRB 718 5pm)
Lecturer: Ruggles

Reading List

• Design and Analysis of Experiments by Douglas C. Montgomery

• Adaptive clinical trials in oncology by Donald A. Berry, Nature Reviews Clinical Oncology 9 (2012) 199-207.

• Bias as a threat to the validity of cancer molecular-marker research by David F. Ransohoff, Nat Rev Cancer 5 (2005) 142-149

Additional Reading

• Essentials of Clinical Research by Stephen P. Glasser

• Handbook for Good Clinical Research Practice (GPC - WHO)

Lecture 11 Signal Processing (November 10, 2015 TRB 718 5pm)
Lecturer: Fenyo

Additional Reading

• Coursera Digital Signal Processing

Lecture 12 Pathways and Networks (November 17, 2015 TRB 718 5pm)
Lecturer: Fenyo

Reading List

• All of Statistics by Larry Wasserman, Chapters 16-18

• The Algorithm Design Manual by Steven S Skiena, Chapter 5

Additional Reading
• *An Introduction to Systems Biology: Design Principles of Biological Circuits by Uri Alon* Chapters 1-4

• *Computational Modelling Of Gene Regulatory Networks - A Primer by Hamid Bolouri*

• *Coursera: Probabilistic Graphical Models*

**Lecture 13** Modeling and Simulation (November 24, 5RB 718 5pm)
Lecturer: Fenyo

*RReading List*

• *All of Statistics by Larry Wasserman, Chapters 23-24*

• *Modeling Complex Systems by Nino Boccara Chapters 1-2*

*Additional Reading*

• *Evolutionary Dynamics: Exploring the Equations of Life by Martin A. Nowak*

• *Coursera: Dynamic Modeling Methods for Systems Biology*

• Monte Carlo Statistical Methods by Robert & Casella

**Lecture 14** Project Presentation (December 15, 2015 TRB 718 5pm)