BENG 134 F21: Measurements, Statistics, and Probabilities

A combined lecture and project-based course offering an introductory treatment of probability theory, including distribution functions, random variables, and timeseries. We will focus on practical application, and on complexities and confounds arising from the use of models in biological / biomedical systems.

Week 1: Overview of the course, expectations, homework and exams, and interplay of lab and lectures.

Introduction to matrices.
Linear algebra refresher.

Week 2: Distributions and Probabilities

Parametric vs non-parametric, skew, multimodality and complexity from overlap.
Probability and probability notation

Week 3: Randomness and random numbers giving rise to structure (fractals?)

Energetics as a constraint on manifestation and patterns
Considering "randomness" vs complexity
Simulated data, noise/de-noising and considerations in biology

Week 4: Introduction to Bayesians:

Bayesian reasoning, estimation
ROC curves and model outputs
Z scores and transformations

Week 5: Regression

Arguments against linearity 1: log scales in biological processes from evo to mech
linear, log, mixed linear models, etc
Exam 1

Week 6: Goodness of fit

error and residuals as useful features in and of themselves in biology
other fits – sum of sines, etc

Week 7: Frequency space and wavelets

Arguments against linearity 2: Biological rhythms and neuroendocrine mechanisms
Generating more interesting dimensions to reduce

Week 8: Networks, graph theory, and coupled oscillators.

Week 9: Eigenvalues and eigenvectors and PCA

Dimensional reduction
Considerations for seeing into unimaginable complexity

Week 10: Markov processes and hidden Markov models.

Week 11: Exam 2

Weekly syllabus for BENG 134 sections & project, Fall 2021
(remote, Prof. Benjamin Smarr & Patrick Kasl)

Week 1: Introductions to each other and to the class project.
Introduce your motivation; identify relevant strengths; identifies skills you'd like to build.
Outline project expectations & flow of the lab portion of the course.
Find partners who might help complement these skills across the course.
Homework – finalize your group selections.

Week 2: Framing questions, hypotheses, predictions, etc.
Discussion and lecture to differentiate **Q**uestions, **H**ypotheses, **P**redictions, and **T**est.
Real world examples, writing examples for Specific Aims pages.
Homework – draft your proposal and explicitly list the topics you're using from class.

Week 3: Proposal peer-review and approval.
Trade proposals with 2 other groups (split the groups to receive feedback in parallel).
Polish proposal based on feedback (reunite to align comments).
Homework – finish polish and turn in proposals for instructor review.

Week 4: Goods and bads of data gathering.
Constraints of human subjects, introductions to IRBs.
How to identify and address limitations in data sets.
Homework – solidify data sources if you have not; write paragraphs on data use and limitations.

Week 5: Analytic plans and data trouble shooting
Check in that everyone is generating or accessing data, troubleshoot as needed.
Homework – finalize troubleshooting, get instructor approval of function

Week 6: Break for midterm – work on generating data!

Week 6: Overfitting, uncertainty, and logical discourse
Discuss the power of advanced analytics to overcome traditional science hurdles
Discuss the difference between "publishable" and "good science"
*Homework – write draft methods and **I**nterpretations sections.*

Week 7: Draft presentations.
Make cross-group trios; each individual describes their Q, H, P, T, and I. (5 min, timed).
Give feedback on what was clear and what needs work. Be frank, thorough, and constructive.
Homework: Align commentary with your group. Seek clarification for individuals and the report.

Week 8: NoteBooks as papers
Ensuring reproducibility, explicability, and maintaining a clear story.
Homework – write introduction and conclusion sections, folding in Q, H, P, T, and I.

Week 9: Finalize results & visualizations
Workshop notebooks, ensure completion of analysis and clear labeling of code sections.
Homework – present notebooks for instructor approval.

Week 10: Final *live* notebook presentations 1.
10 min presentation by each group, from Q through Conclusions, 10 min for Q&A.

Week 11: Final *live* notebook presentations 2
10 min presentation by each group, from Q through Conclusions, 10 min for Q&A.

Grades:

55% of the course grade will come from the project component, and 45% from the lecture component.

Within the project component, 22% will be assigned for completion of each weekly assignment, 11% for participation in group activities, and 22% for the final presentation (comes to 5% per week x 11 weeks).

Within the lecture, 5% will be assigned to each of 5 home works, and 10% to each of 2 exams.

All lectures, sections, and exams will be virtual.