Bioinformatics 800: Special Topics Course

Mathematics of Biological Networks

Winter 2016 (4 credit hrs.)
Instructor: Prof. Indika Rajapakse (E-mail: indikar@umich.edu)
Lecture: Tues. & Thurs., 8:30 AM – 10:00 AM
Room: 2062 Palmer Commons Building.
Lab: Wed. 1:00 PM – 2:00 PM OR 2:00 PM – 3:00 PM
Room: 2036 Palmer Commons Building

Description: This course addresses methods and principles involved in constructing and studying the structure and function of biological networks using examples from real datasets (emphasis on genome-wide chromosome conformation capture (Hi-C), RNA-seq, and imaging). It includes learning basic mathematical principles required for understanding biological networks, plus introduces important questions in the field. The course is structured so that any necessary background will be introduced as needed. A comprehensive website containing all reading materials and class notes will be maintained throughout the term.

The course will begin with a discussion of some of the general properties of networks. I will teach a lot of linear algebra during this course. I will start from very basics. I will never forget my amazement at learning that combinatorial properties of graphs could be revealed by an examination of the eigenvalues and eigenvectors of their associated matrices. I hope to convey this amazement while making the methods in this line of study feel like common sense. Below are some topics that will likely be covered in this course.

- Review of basic probability theory
- Spectral graph theory: The eigenvalues and eigenvectors of matrices associated with graphs, and their applications
- Singular value decomposition
- Higher-order singular value decomposition
- Many examples of graphs and their Laplacians. Fiedler number and Fiedler vector
- Clustering
- Dynamic mode decomposition and proper orthogonal decomposition on networks
- From a single network to a network of networks
- Network controllability

Workload: There is a computing assignment every two weeks (approximately), and associated with every lecture there is a "Problem of the Day (POD)" which should be worked out. They are not submitted for grading but you should take them seriously. The PODs are a valuable way to keep up with the course.

Some linear algebra references: Gil Strang’s MIT Linear Algebra course videos and text are excellent.