PHC 6067
Probabilistic Graphical Models

PREREQUISITE: **PHC6065, PHC6064 (optional)**

COURSE DESCRIPTION: **Concepts and implementation of Probabilistic Graphical Models, comparative study the models, and their suitability for various datasets.**

COURSE OBJECTIVES:

Complex systems are characterized by the presence of multiple interrelated aspects, many of which relate to the reasoning task. For example, in our public health data analyses, there are multiple possible diseases that the patient might have, dozens or hundreds of symptoms and risk factors, personal characteristics that often form predisposing factors for disease, and many more matters to consider. This course is designed to give students a thorough grounding in the methodologies, technologies, mathematics and algorithms currently needed by people who do research in multivariable data analyses using probabilistic graphical models, e.g., Bayesian networks, Hidden Markov Models, etc., or who may need to apply multivariable data analyses using probabilistic graphical models to a target problem.

The topics of the course draw from classical statistics, from statistical learning, from data mining, from Bayesian statistics and from statistical algorithms.

Students entering the class with a pre-existing working knowledge of probability, statistics and algorithms will be at an advantage, but the class has been designed so that anyone with a strong numerate background can catch up and fully participate.

INSTRUCTOR:

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TEXT BOOK:

Probabilistic Graphical Models Principles and Techniques by Daphne Koller and Nir Friedman

Evaluation and assessment:

Assignments:

Readings as assigned with the homework.
Homework exercises and assignments.
Posted online and submission will be accepted through online

GRADING:

midterm (20%), homework (25%), and final exam + final project (55%)

Late assignments will be penalized 25% per day. Assignments that are more than 3 days late will get no credit.

Meetings (2016):

Lectures: TBA

Overview of course structure and policies

The class will meet once per week for two hours, 40 minutes. The class sessions will consist of lectures, class discussions, student presentations, and examinations. Students are responsible for reading and completing all assignments prior to class. Students will be graded on quizzes, exams, an oral presentation, participation, and a final paper. The instructor reserves the right to amend the syllabus and assign additional readings during the semester. It is the student's responsibility to check the course material periodically for updates.

Attendance

Attendance will not be formally recorded. However, class attendance is required. Students who do not attend class will likely have poor performance on quizzes and exams given that quiz and exam questions will closely reflect problems covered in class. In addition, students should note that there are student presentations, quizzes, or exams on most class sessions, so failing to attend class will result in missing presentations, quizzes, and/or exams which **cannot be made up**.

Participation

Participation will be evaluated based on the student's level of participation in class during the semester. Students are expected to actively participate in class lectures. Students must be in class to participate in class lectures so don't miss class.

Class Project

Advanced students are expected to complete a research project on a relevant topic. The specific problem requires the instructor's approval. Possible projects include, but are not limited to, an application of a particular model and technique to a specific problem, the development of a system based on graphical model ideas to solve a particular problem for a particular application domain, or novel experimental evaluations and comparisons of one or various computational techniques. Ideally, the project would incorporate a combination of theoretical and experimental work. Projects that involve exclusively theoretical work may be permitted only under very close consultation with the instructor and should involve a narrowly and clearly defined problem description and line-of-attack. Students periodically submit progress reports to monitor the project's development. Students give a presentation and submit a written report on the results of the project by the end of the course.

Student Conduct

Students are responsible for knowing and complying with all Florida International University Policies and Regulations which are listed in the Student Handbook. Students should pay particular attention to the Code of Academic Integrity. Any student that exhibits misconduct will be subject to the Academic Misconduct procedures and sanctions, as outlined in the Student Handbook It is important for all students to understand that plagiarism and cheating are serious offenses punishable by expulsion from the University. Finally, students who at any time disrespect the instructor or any fellow student will be asked to leave the class.

Grading

A	92.6-100%	C	69.6-79.5%
A-	89.6-92.5%	D	59.6-69.5%
B+	86.6-89.5%	F	59.5-0%
B	82.6-86.5%		
B-	79.6-82.5%		

Tentative Schedule*:

Week	Lecture	Notes
1	Welcome! Review of Probability	
2	Introduction and Overview • Overview and Motivation • Distributions • Factors	Chapter 1. Chapters 2.1.1 to 2.1.3. Chapter 4.2.1.
3	Bayesian Network Fundamentals • Semantics and Factorization • Reasoning Patterns. • Flow of Probabilistic Influence. • Conditional Independence. Independencies in Bayesian Networks. • Naive Bayes. • Application - Medical Diagnosis	Chapters 3.2.1, 3.2.2. Chapter 3.2.1 Chapter 3.3.1 Chapters 2.1.4, 3.1 Chapter 3.2.2 Chapter 3.1.3 Chapter 3.2: Box 3.D (p. 67)
4	Template Models • Overview. • Temporal Models - DBNs. • Temporal Models - HMMs.	Chapter 6.1 Chapters 6.2, 6.3.
5	Structured CPDs • Overview. • Tree-Structured CPDs. • Independence of Causal Influence. • Continuous Variables.	Chapters 5.1, 5.2. Chapter 5.3. Chapter 5.4. Chapter 5.5.
6	Markov Network Fundamentals • Pairwise Markov Networks. • General Gibbs Distribution. • Conditional Random Fields. • Independencies in Markov Networks. • Maps and Perfect Maps. • Log-Linear Models. • Shared Features in Log-Linear Models.	Chapter 4.1. Chapter 4.2.2. Chapter 4.6.1. Chapter 4.3.1. Chapter 3.3.4. Chapter 4.4, p. 125. Chapter 4: Box 4.B (p. 112), Box 4.C (p. 126), Box 4.D (p. 127).
7	Variable Elimination • Conditional Probability Queries. • MAP Queries. • Variable Elimination Algorithm. • Variable Elimination Complexity. • VE - Graph Based Perspective. • Finding Elimination Orderings.	**Class Project Proposal Due** Chapter 9.3. Chapter 13.2.1. Chapter 9.2. Chapter 9.4 through 9.4.2.3. Chapter 9.4.3.
8	Belief Propagation • Belief Propagation. • Properties of Cluster Graphs.	Chapter 11.3.2 Chapter 11.3.3 Chapter 10.2.1

	• Properties of Belief Propagation. • Clique Tree Algorithm - Correctness. • Clique Tree Algorithm - Computation. • Clique Trees and Independence. Clique Trees and VE. MAP Estimation • MAP Exact Inference. • Finding a MAP Assignment.	Chapters 10.2.2, 10.3.3.1 Chapter 10.1.2 Chapter 10.4.1 Chapter 13.2.1 Chapter 13.2.2 Chapter 13.6.
9	**Midterm Exam**	
10	Sampling Methods (combined slides) • Simple Sampling. • Markov Chain Monte Carlo . • Using a Markov Chain. Gibbs Sampling.	Chapter 12.1. Chapter 12.3 up to 12.3.2.2. Chapter 12.3.5. Review of Chapter 12.3.2 as applied to Gibbs Sampling. Chapter 12.3.4.2.
11	Inference in Temporal Models / Decision Making (combined slides) • Maximum Expected Utility • Utility Functions • Value of Perfect Information	Chapter 22.1.1, 23.2.104, 23.4.1-2, 23.5.1 Chapter 22.2.1-3, 22.3.2, 22.4.2 Chapter 23.7.1-2
12	Learning: Parameter Estimation • Overview. Maximum Likelihood Estimation. Maximum Likelihood Estimation for Bayesian Networks. • Bayesian Estimation. • Bayesian Prediction. • Bayesian Estimation for Bayesian Networks • Maximum Likelihood Estimation for Log-Linear Models. • Maximum Likelihood Estimation for Conditional Random Fields. • MAP Estimation for Markov Random Fields and Conditional Random Fields.	Chapter 16.1 and Intro to Chapter 17 Chapter 17.1 Chapter 17.2 through 17.2.1 Chapter 17.3.2 Chapter 17.4 Chapter 20.1 - 20.2
13	Thanksgiving Break	
14	Structure Learning and Causality • Overview • Likelihood Scores • BIC and Asymptotic Consistency • Bayesian Score • Learning Tree Structured Networks • Learning General Graphs: Heuristic Search • Learning General Graphs: Heuristic Search and Decomposability • Causality	Chapter 18.1 Chapter 18.3.1 Chapter 18.3.5 Chapter 18.3.2-18.3.4, 18.3.6, 18.3.7 Chapter 18.4.1 Chapter 18.4.3.1-2 Chapter 18.4.3.3 Chapter 21
15	Learning With Incomplete Data and Causality • Overview • Expectation Maximization - Intro • Analysis of EM Algorithm • Latent Variables • Causality	Chapter 19.1.3 and 19.1.4 Chapter 19.2.2 Chapter 19.2.2 Chapter 21
16	**Final Exam**	TBA

* This is a tentative schedule. This schedule is subject to change.