Ahmedabad University

Course	CSE516 Probabilistic Graphical Models	Semester	Monsoon Semester 2024
Faculty Name(s)	Dhaval Patel	Contact	dhaval.patel@ahduni.edu.in
School	SEAS	Credits	3
GER Category:	Not Applicable	Teaching Pedagogy Enable:NO	P/NP Course: Can not be taken as P/NP

Schedule

Section 1	09:30 am to 11:00 am	Fri	01-08-24 to 26-11-24
	11:00 am to 12:30 pm	Fri	01-08-24 to 26-11-24

Prerequisite	Not Applicable
Antirequisite	Not Applicable
Corequisite	Not Applicable
Course Description	Probability theory and Graph modelling (PGM) play a key role in the design of a system across many disciplines like Artificial Intelligence, statistics, Life Sciences -computational biology, Computer Systems, Intelligent Transports, Robotics, Economics etc. Such field treated as “the search for a coherent global conclusion from local information”.The PGM framework provides a unified view for this wide range of problems, enabling efficient inference, decision-making and learning in problems with a very large number of attributes and huge datasets. PGMs bring together graph theory and probability theory and provide a flexible framework for modelling large collections of random variables with complex interactions. The course will focus mainly on three aspects: A. The core representation, including Bayesian and Markov networks, and dynamic Bayesian networks; B. Probabilistic inference algorithms, both exact and approximate; and C. Learning methods for both the parameters and the structure of graphical models. Students entering the class should have a pre-existing working knowledge of probability, statistics, and algorithms. This class will set the foundation for machine learning, predictive analytics, reinforcement learning, natural language processing etc. Students can apply PGM in any field of core computer science and engineering to handle multidimensional uncertain problems.

Course Objectives	The objectives of this course are: · To learn about probability models and graph theory · Modeling multivariate problem using probabilistic graph models · To learn about the interaction of multiple random variables and their modelling. -To learn the representation, Inference, learning, actions and decisions based on graph models.
Learning Outcomes	1. Gain working knowledge of multivariate probabilistic modelling 2. Derive an inference for practical applications 3. Formulate and solve a wide range of problems in their own domain using graphical models 4. Setting a foundation for machine learning / Deep learning / Reinforcement learning / Natural Language Processing / Computer Vision
Pedagogy	Lectures, tutorials (Problem solving) and Piazza discussion , Interdisciplinary Problem solving
Expectation From Students	Regular attendance, pre-reading is the must. Students are expected to correlate the everyday life's uncertainty and engineering applications in the class/tutorial discussions

Assessment/Evaluation	• End Semester Examination:
	  ◦ Written - 25%
	• Other Components:
	  ◦ Quiz - 20%
	  ◦ Project - 40%
	  ◦ Class Activities : Hands on tasks, group work, class discussion - 15%

Attendance Policy	As per Ahmedabad University Policy.
Project / Assignment Details	There are few homework problems based on student interests which may have higher % than regular assignments.

Course Material	
Additional Information	Text Book: Daphne Koller and Nir Friedman, Probabilistic Graphical Models: Principles and Techniques, The MIT Press.

Session Plan

NO.	TOPIC TITLE	TOPIC & SUBTOPIC DETAILS	READINGS,CASES,ETC.	ACTIVITIES	IMPORTANT DATES
1	Introduction, Probability Theory, Bayesian Networks	Fundamentals of probability	Chapter 1-3	Lecture	
2	Introduction, Probability Theory, Bayesian Networks	Continuous and discrete random variables, PDF, CDF, PMF	Chapter 1-3		
3	Introduction, Probability Theory, Bayesian Networks	Graph Tehory # 1	Chapter 1-3		
4	Introduction, Probability Theory, Bayesian Networks	Graph Tehory # 2	Chapter 1-3		
5	Introduction, Probability Theory, Bayesian Networks	Graph Tehory # 3	Chapter 1-3		
6	Introduction, Probability Theory, Bayesian Networks	Motivation of probabilistic graph models : Overview of Representation, inference, learning. Basics of Graph theory.	Chapter 1-3	Lecture	
7	Undirected models	Undirected graphical models : Parameterization	Chapter 4	Lecture	
8	Undirected models	Markov Network independencies	Chapter 4	Lecture	
9	Undirected models	Bayesian networks and Markov networks	Chapter 4	Lecture	
10	Learning Bayes Nets	Learning Bayes Nets : Motivation and goals of learning	Chapter 16-17	Lecture	

11	Learning Bayes Nets	Learning as Optimization and learning tasks	Chapter 16-17	Lecture	
12	Learning Bayes Nets	Bayesian parameter estimation	Chapter 16-17	Lecture	
13	Exact Inference; Message Passing	Variable Elimination: Complexity and graph structure	Chapter 9-10	Lecture	
14	Exact Inference; Message Passing	Sum-Product Message Passing	Chapter 9-10	Lecture	
15	Exact Inference; Message Passing	Message passing: Belief update	Chapter 9-10	Lecture	
16	Sampling	Forward sampling, Markov chain Monte Carlo methods	Chapter 12	Lecture	
17	MAP Inference; Structured prediction	MAP Inference; Structured prediction	Chapter 13	Lecture	
18	Parameter Learning	Parameter Learning : Basics, parameter estimation	Chapter 19-20	Lecture	
19	Parameter Learning	learning with incomplete data			
20	Parameter Learning	Models with hidden variables			
21	Parameter Learning	Applications			
22	Bayesian Learning; Structure Learning	Bayesian Learning; Structure Learning	Chapter 17-18	Lecture	
23	Exponential families; variational inference	Exponential families: Linear and factored exponential families	Chapter 8	Lecture	
24	Exponential families; variational inference	Entropy and relative entropy	Chapter 8	Lecture	

25	Exponential families; variational inference	M-projections, I-projections and comparison	Chapter 8	Lecture	
26	Exponential families; variational inference	Variational inference	Chapter 11	Lecture	
27	Exponential families; variational inference	Inference as optimization	Chapter 11	Lecture	
28	Exponential families; variational inference	Exact inference as optimization	Chapter 11	Lecture	
29	Recitation Session # 1	Revision#1, doubt/problem solving		Problem solving	
30	Recitation Session # 2	Revision#2, doubt/problem solving		Problem solving	