BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI

WORK INTEGRATED LEARNING PROGRAMMES

Digital

Part A: Content Design

Course Title	Probabilistic Graphical Model
Course No(s)	
Credit Units	4
Credit Model	1 - 0.5 - 1.5. 1 unit for class room hours, 0.5 unit for Tutorial, 1.5 units for Student preparation. 1 unit = 32 hours
Content Authors	Ms. Seetha Parameswaran
Version	1.0
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Course Objectives

No	Course Objective
CO1	Introduce students to the basic concepts and techniques of Probabilistic Graphical Model.
CO2	Students will be able to compute conditional distributions from simple discrete probabilistic models, like a fixed Naïve Bayes classifier, a finite mixture model or a Hidden Markov Model.
CO3	Students will be able to explain the model structure learning problem and parameter learning problem.
CO4	Students will be able to develop skills of using recent probabilistic graphical models to evaluate learning algorithms.

Text Book(s)

T1	Mastering Probabilistic Graphical Models using Python by Ankur Ankan, Abhinash Panda. Packt Publishing 2015.
T2	Building Probabilistic Graphical Models with Python by Kiran R Karkera. Packt Publishing 2014.

Reference Book(s) & other resources

R1	Probabilistic Graphical Models: Principles and Techniques by Daphne Koller and Nir Friedman. MIT Press. 2009
R2	Learning in Graphical Models by Michael I. Jordan. MIT Press. 1999

Content Structure

1. Introduction
   - 1.1. Objective of the course
   - 1.2. Structured Probabilistic Models

2. Mathematical Preliminaries
   - 2.1. Probability Theory
   - 2.2. Graph

3. Directed Graphical Models
   - 3.1. Bayes Networks
   - 3.2. D-separation
   - 3.3. I-map

4. Undirected Graphical Models
   - 4.1. Markov Networks
   - 4.2. Gibbs distributions
   - 4.3. Factorization

5. Exact Inference
   - 5.1. Variable Inference
   - 5.2. Belief Propagation
   - 5.3. MAP using belief propagation

6. Approximate Inference
   - 6.1. Propagation based approximation algorithm
   - 6.2. Loopy Belief propagation
   - 6.3. Sampling based approximate messages
   - 6.4. Markov chain Monte Carlo methods

7. Parameter Learning
   - 7.1. Parameter Estimation in Bayesian Networks
   - 7.2. Maximum Likelihood Estimation
   - 7.3. Parameter Estimation in Markov Networks

8. Structure Learning
   - 8.1. Structure learning in Bayesian Networks
   - 8.2. Constraint based structure learning
   - 8.3. Score based constraint learning

9. Models
   - 9.1. Naïve Bayes Model
   - 9.2. Hidden Markov Model

Learning Outcomes:

No	Learning Outcomes
LO1	Able to understand the basics of Probabilistic Graphical Models.
LO2	Able to solve problems related to Probabilistic Graphical Models using appropriate learning techniques.
LO3	Able to identify appropriate tools to implement the solutions to problems related to Probabilistic Graphical Models and implement solutions.

Part B: Learning Plan

Academic Term	
Course Title	Probabilistic Graphical Model
Course No	
Lead Instructor	

Session No.	Topic Title	Study / HW Resource Reference
1	Introduction Objective of the course, Structured Probabilistic Models, Representation, Inference, Learning, Application of Probabilistic Graphical Models.	R1 – Ch1
2	Mathematical Preliminaries Probability theory, Probability Distributions, Random Variables and Joint Distributions, Independence and Conditional Independence, Expectation and Variance Graphs, Nodes and Edges, Subgraphs, Paths and Trails, Cycles and Loops	T1 – Ch1 T2 – Ch1
3	Directed Graphical Models Independence and independent parameters, Bayesian models, Representation, Factorization of a distribution over a network, Bayesian model representation	T1 – Ch1
4	Directed Graphical Models (contd) D-separation, IMAP, IMAP to factorization, CPD representations, Implementing Bayesian networks using pgmpy	T1 – Ch1

5	Undirected Graphical Models Markov network, Parameterizing a Markov network – factor, Factor operations, Gibbs distributions and Markov networks, Factor graph	T1 – Ch2
6	Undirected Graphical Models (contd) Independencies in Markov networks, Constructing graphs from distributions Bayesian and Markov networks	T1 – Ch2
7	Exact Inference Variable elimination, Belief propagation, Constructing a clique tree, MAP using variable elimination, Factor maximization, MAP using belief propagation, Finding the most probable assignment, Predictions from the model using pgmpy	T1 – Ch3
8	Review of Session 1 to 7	Books, Web references and Slides
9	Approximate Inference Exact inference as an optimization, Propagation-based approximation algorithm, Loopy Belief propagation , Propagation with approximate messages, Sampling-based approximate methods, Markov chain Monte Carlo methods, Using a Markov chain	T1 – Ch4 T2 – Ch7
10	Parameter Learning General ideas in learning, Learning as an optimization, Maximum likelihood estimation, Parameter Estimation in Bayesian Networks, MLE for Bayesian networks	T1 – Ch5, Ch6 T2 – Ch5
11	Parameter Learning (contd) Parameter Estimation in Markov Networks, MLE for Markov models	T1 – Ch5, Ch6 T2 – Ch5
12	Structure Learning Structure learning in Bayesian networks, Methods for the learning structure, Constraint-based structure learning, Structure score learning, Bayesian score for Bayesian networks	T1 – Ch5, Ch6 T2 – Ch4
13	Structure Learning (contd) Structure learning in Markov Models, Constraint-based structure learning, Structure score learning	T1 – Ch5, Ch6 T2 – Ch4

14	Naïve Bayes Model, Implementation	T1 – Ch7
15	Hidden Markov Model, Implementation	T1 – Ch7
16	Review of session 9 to 15	Books, Web references and Slides

Detailed Plan for Lab work

Lab No.	Lab Objective	Lab Sheet Access URL	Session Reference
1	Bayesian model representation		4
2	Markov Model representation		6
3	MAP on Bayesian model		7
4	MLE on Bayesian Model		10
5	MLE on Markov Model		11
6	Learning Structure in Bayesian Model		12

Evaluation Scheme:
Legend: EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

No	Name	Type	Duration	Weight	Day, Date, Session, Time
EC-1	Quizzes	Online		10%	
EC-2	Assignments	Take Home		20%	
EC-3	Mid-Semester Test	Closed Book	1.5 Hrs	30%	
EC-4	Comprehensive Exam	Open Book	2.5 Hrs	40%	

Note:
Syllabus for Mid-Semester Test (Closed Book): Topics in Session Nos. 1 to 8
Syllabus for Comprehensive Exam (Open Book): All topics (Session Nos. 1 to 16)

Important links and information:

Elearn portal: https://elearn.bits-pilani.ac.in or Canvas
Students are expected to visit the Elearn portal on a regular basis and stay up to date with the latest announcements and deadlines.

Contact sessions: Students should attend the online lectures as per the schedule provided on the Elearn portal.

Evaluation Guidelines:

1. EC-1 consists of two Quizzes. Students will attempt them through the course pages on the Elearn portal. Announcements will be made on the portal, in a timely manner.
2. EC-2 consists of either one or two Assignments. Students will attempt them through the course pages on the Elearn portal. Announcements will be made on the portal, in a timely manner.
3. For Closed Book tests: No books or reference material of any kind will be permitted.
4. For Open Book exams: Use of books and any printed / written reference material (filed or bound) is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
5. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam which will be made available on the Elearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course hand-out, attend the online lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid-Semester Test and Comprehensive Exam according to the evaluation scheme provided in the hand-out.