

# GEORGIA INSTITUTE OF TECHNOLOGY

ECE/CS/ISYE 8803  
Probabilistic Graphical Models in Machine Learning  
Spring Semester 2018

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## Topical Outline:

### 1. Bayesian networks (Representation)

- a. Examples (HMM, diagnostic system, etc.)
- b. Separation and independence
- c. Markov properties and minimalism
- d. Applications to time series model, topic modeling and network modeling

### 2. Markov networks (Representation)

- a. Examples (Boltzmann machine, Markov random field, Ising models)
- b. Cliques and potentials
- c. Markov properties
- d. Factor graphs
- e. Applications to image modeling, and network modeling

### 3. Gaussian network models and exponential family

- a. Multivariate Gaussians and Gaussian Networks
- b. Exponential families
- c. Information Theory

### 4. Exact inference (Inference)

- a. Complexity
- b. Variable elimination
- c. Belief propagation (message passing) on trees
- d. Sum- and Max-product algorithms
- e. Clique tree, Junction tree
- f. Application to HMM

### 5. Inference and sampling methods (Inference)

- a. MCMC method
- b. Gibbs sampling
- c. Importance sampling
- d. Particle filtering

6. Approximate inference (Inference)

- a. Loopy belief propagation
- b. Variational inference and optimization view of inference
- c. Mean field approach

7. Parameter learning (Learning)

- a. Parameterizing graphical models
- b. Parameter estimation in fully observed Bayesian networks
  - Maximum likelihood estimation
  - Bayesian parameter estimation
  - Examples: HMM, etc.
- c. Parameter estimation in fully observed Markov networks
  - Maximum likelihood estimation
    - o Iterative Proportional Fitting (IPF)
    - o Generalized Iterative Scaling (GIS)
- d. Parameter estimation in partially observed graphical models
  - Expectation-Maximization (EM)
  - Examples: HMM, etc.
- e. Learning Conditional Random Fields

8. Structure learning (Learning)

- a. Score based approach
- b. Chow-Liu algorithm for Bayesian networks
- c.  $l_1$ -regularized convex optimization for Markov random fields
- d. Low-rank regularized learning of latent variable models

9. Nonparametric Bayes methods (Learning) (time permitting)

- a. Gaussian processes
- b. Dirichlet processes
- c. Indian Buffet processes