Graphical Models

Rationale

Probabilistic graphical models have been applied to various domains for modeling and reasoning uncertain information. This course will provide students with essential backgrounds on these methods.

Course Description

Probabilistic graphical models, especially Bayesian networks, offer a compact, intuitive, and efficient graphical representation of uncertain relationships among the variables in a domain and have proven their value in many disciplines, including machine or medical diagnosis, prognosis, bioinformatics, planning, user modeling, natural language processing, vision, robotics, data mining, fraud detection, and many others. This course will familiarize you with the basics of graphical models and provide a foundation for applying graphical models to complex problems. Topics include basic representations, exact inference, approximate inference, parameter learning, structure learning, and applications.

Topic List

The topic list may include but is not limited to: Bayesian network

Examples (HMM, diagnostic system, etc.) Separation and independence Markov properties and minimalism

Markov network

Examples (Boltzmann machine, Markov random field, etc.) Cliques and potentials Markov properties

Exact inference

Complexity Bucket elimination Junction tree Belief propagation (message passing) Application to HMM Sum- and Max-product algorithms

Parameter learning

Exponential family Bayesian learning Expectation-Maximization (EM)

- Bayesian networks

  - Examples (HMM, diagnostic system, etc.)
  - Separation and independence
  - Markov properties and minimalism
- Markov networks
- Undirected Graphical Models
  - Decomposable Graphs
  - Separation and Conditional Independence
  - Junction Trees
  - Examples (Boltzmann machine, Markov random field, etc.)
  - Cliques and potentials
  - Markov properties
- Inference
  - Complexity
  - Bucket elimination
  - Belief propagation (message passing)
  - Application to HMM
  - Sum- and Max-product algorithms
- Parameter learning
  - Exponential family
  - Bayesian learning
  - Expectation-Maximization (EM)
- Model Estimation

Learning Goals

The Learning Goals are to acquaint students with the major topics of probabilistic graphical models in order for them to gain an appreciation of the techniques that are available and the problems that are yet to be solved. Students will be able to

- read and understand technical Changhes describing work in the field of uncertainty artificial intelligence.
- apply knowledge of probability theory to understand the principles behind graphical models and uncertainty reasoning.
- evaluate the applicability of different probabilistic inference methods and determine which is most likely to be most applicable and effective to a specific problem.
- understand different Bayesian methods for learning graphical models from data and conduct experiments to assess their performance.
- identify, formulate, and solve a real-world problem using uncertainty artificial intelligence techniques by collaborating in an interdisciplinary team.

Assessment

There will be a midterm exam (40to assess understanding of the probability theory underlying graphical models and Bayesian Networks. There will be a term project to assess ability to identify, formulate and solve real-world problems using graphical models.