STATISTICAL MACHINE LEARNING
PROBABILISTIC GRAPHICAL MODELS

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GRAPHICAL MODELS

Graphical models:

- They are graphical representations of conditional (in)dependencies of joint probability distributions;
- They allow a more efficient representation of joint p.d.
- They allow faster inference;

We study three kind of GM:

- Bayesian Networks;
- Markov Random Fields;
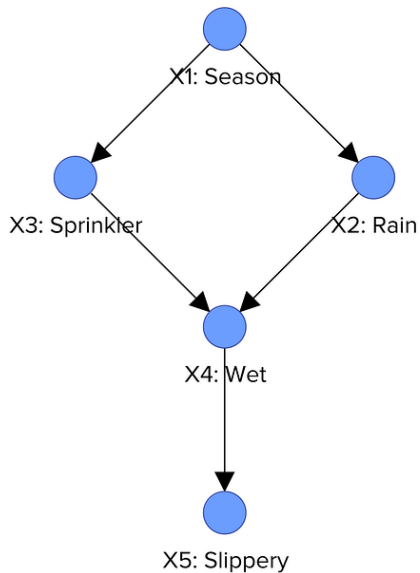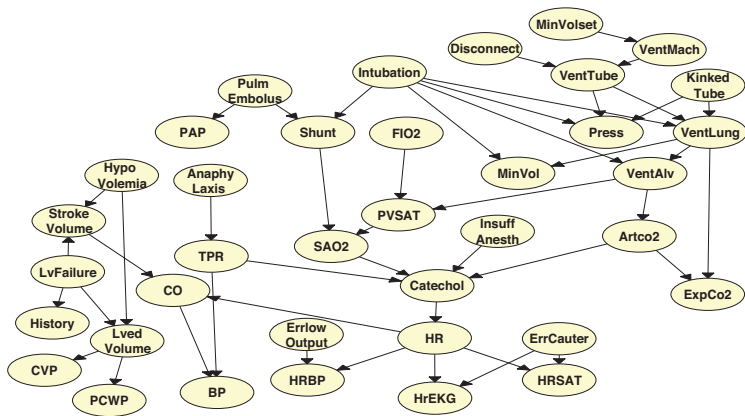- Factor Graphs (for inference)

Outline

BAYESIAN NETWORKS: DEFINITIONS

- Factorization of joint pdf.
- Graphical conventions
- Complexity reduction
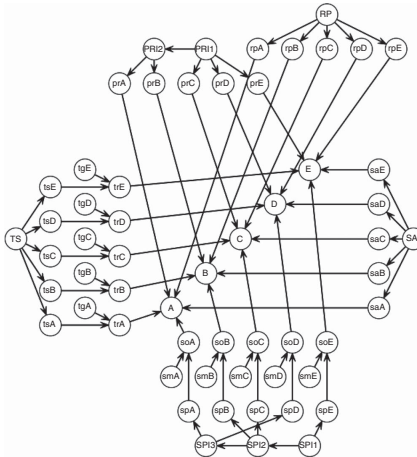- BN as generative models

BAYESIAN NETWORKS: EXAMPLE
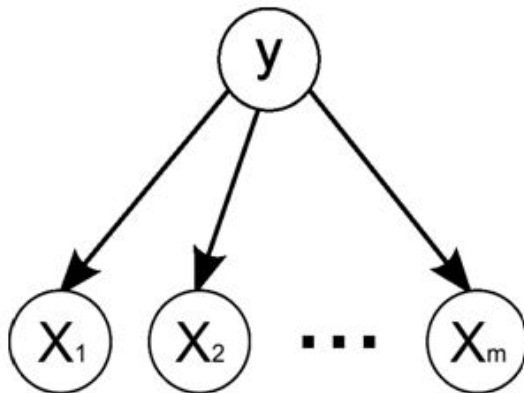
BAYESIAN NETWORKS: EXAMPLE

Expert System: Intensive Care Alarms

BAYESIAN NETWORKS: EXAMPLE

Expert System: Strategies for petroleum exploration

BAYESIAN NETWORKS: EXAMPLE

Naive Bayes Classifier

BAYESIAN NETWORKS: CONDITIONAL INDEPENDENCE

Conditions for conditional independence of *A* and *B* given *C*:

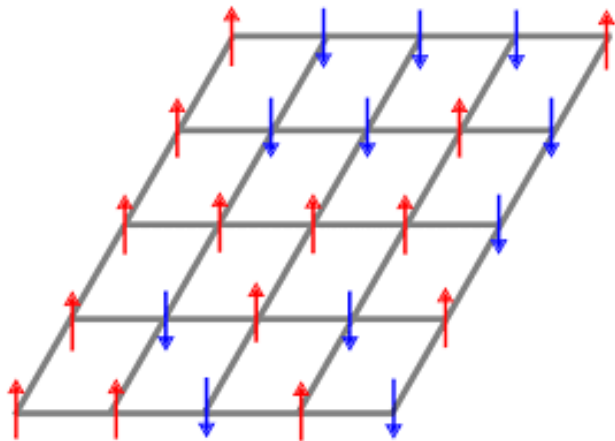- Tail to Tail
- Head to Tail
- Head to Head
- Markov blanket
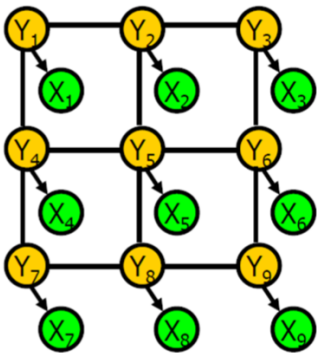
Outline

MARKOV RANDOM FIELDS: DEFINITIONS

- Conditional Independence in MRF
- Factors in MRF
- Joint probability distribution
- Boltzmann distributions

MARKOV RANDOM FIELD: EXAMPLE

Ising Model (binary RVs, energy: Jx_1x_2, per edge (x_1, x_2))
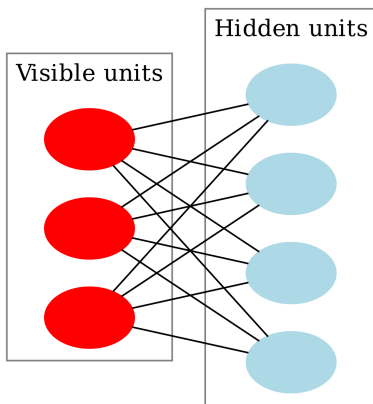
MARKOV RANDOM FIELD: EXAMPLE

Image denoising: $x_{ij}, y_{ij} \in \{0, 1\}$

MARKOV RANDOM FIELD: EXAMPLES

Restricted Boltzmann Machine: bipartite graph, binary nodes

OUTLINE

INFERENCE IN PGM: DEFINITIONS

- Inference goals
- Elimination: idea
- Factor Graphs
- Message passing algorithms in FG: sum-product, max-sum
- Junction trees