Ruprecht-Karls-Universität Heidelberg
Seminar für Computerlinguistik
Institut für allgemeine und angewandte Sprach- und Kulturwissenschaft

Theoretische Grundlagen zu probabilistischer Logik / Belief Networks

Dozent: Nils Reiter
Referentin: Enikö Gross
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Probabilistic Logic

The term probabilistic in our context refers to the use of probabilistic representations and reasoning mechanisms grounded in probability theory, such as Bayesian networks, hidden Markov models and stochastic grammars.

The term logic in the present overview refers to first order logical and relational representations such as those studied within the field of computational logic.

Bayesian networks - BNs

Definition:

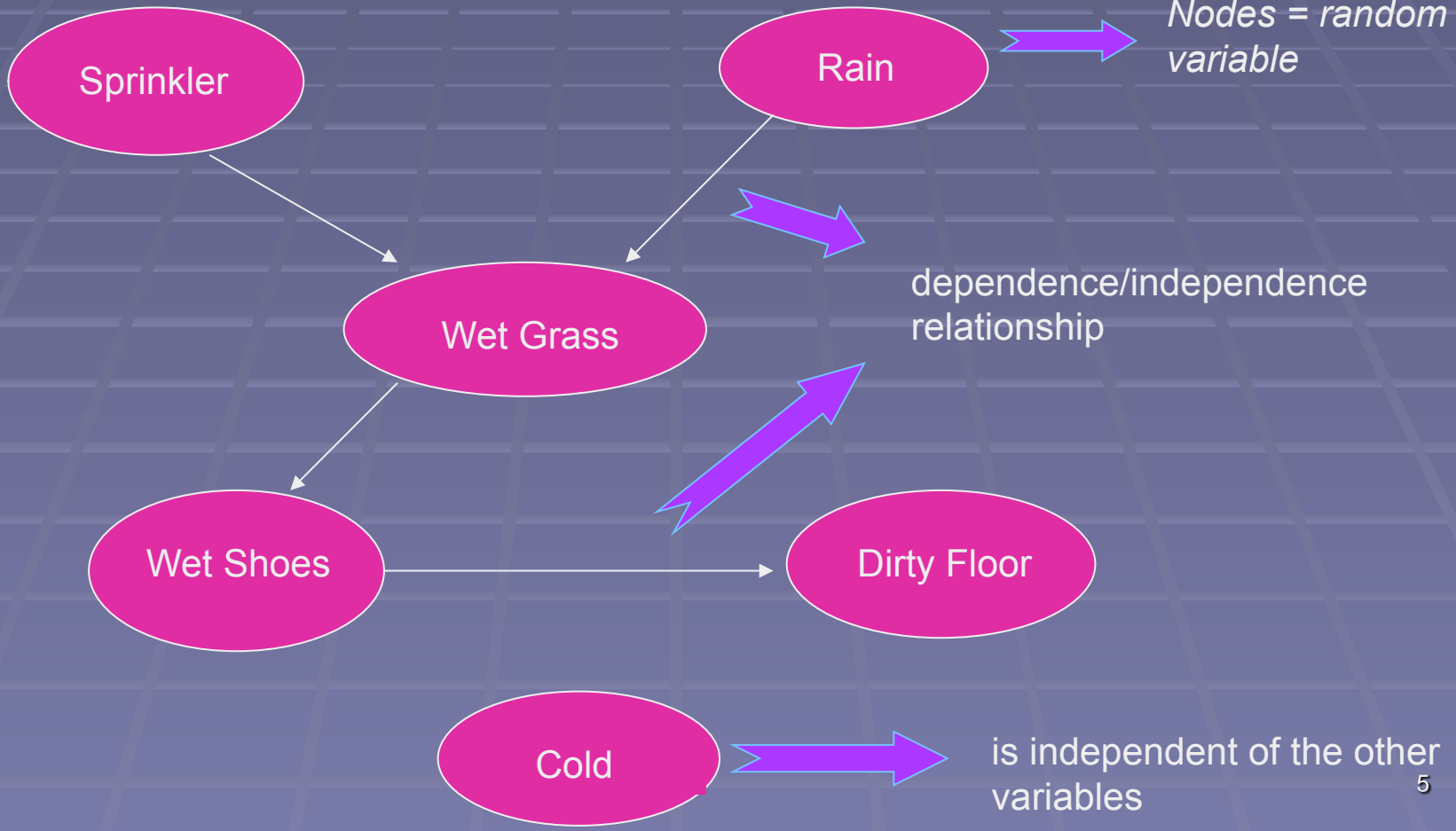
- Bayesian networks are directed acyclic graphs (DAG)
- the nodes represent random variables
- the structure represents the probabilistic dependence or independence relationship between the random variables
- the links represent direct probabilistic influence

- a conditional distribution for each node given its parents μ(***X*i**|Parents(***X*i**))
- conditional distributions are represented by conditional probability tables (CPT)

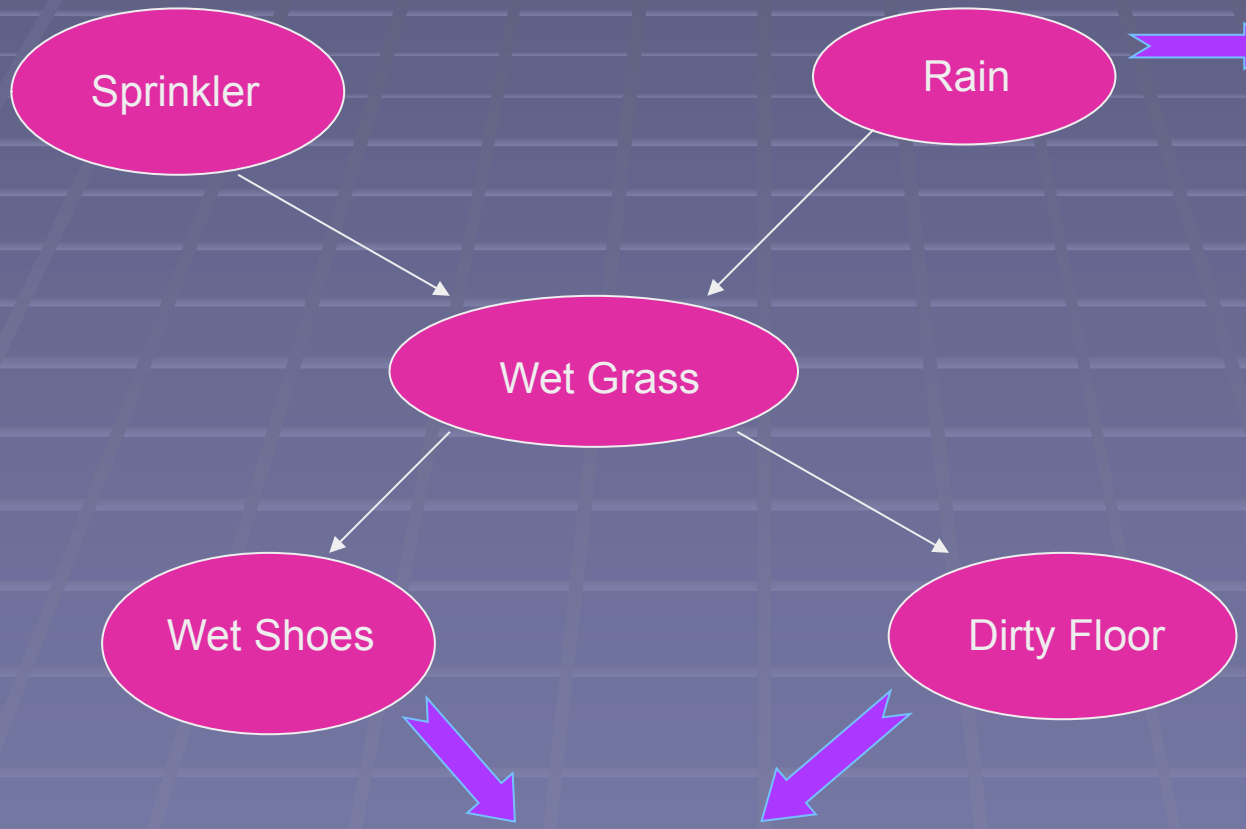
- the joint distribution is defined as the product of the local conditional distribution

$$\mathrm{P}(X_1, \ldots, X_n) = \prod_{i=1}^{n} \mathrm{P}(X_i \mid \mathrm{parents}(X_i)).$$

Bayesian networks/Belief networks



Bayesian networks/Belief networks



Nodes = random variable

S	R	P(W|S,R)
T	T	0.3
T	F	0.8
F	T	0.9
F	F	0.01

Probability table

the two nodes are conditionality independent given WetGrass

Bayesian network/Belief network - Example

→ My shoes are wet from the wet grass before my house, but the floor isn‘t dirty. A little bit rain makes the grass wet. Or was the neighbor‘s sprinkler.

→ Variables: Sprinkler (S), Rain (R), Wetgrass (Wg), Wetshoes (Ws), Dirtyfloor (D)

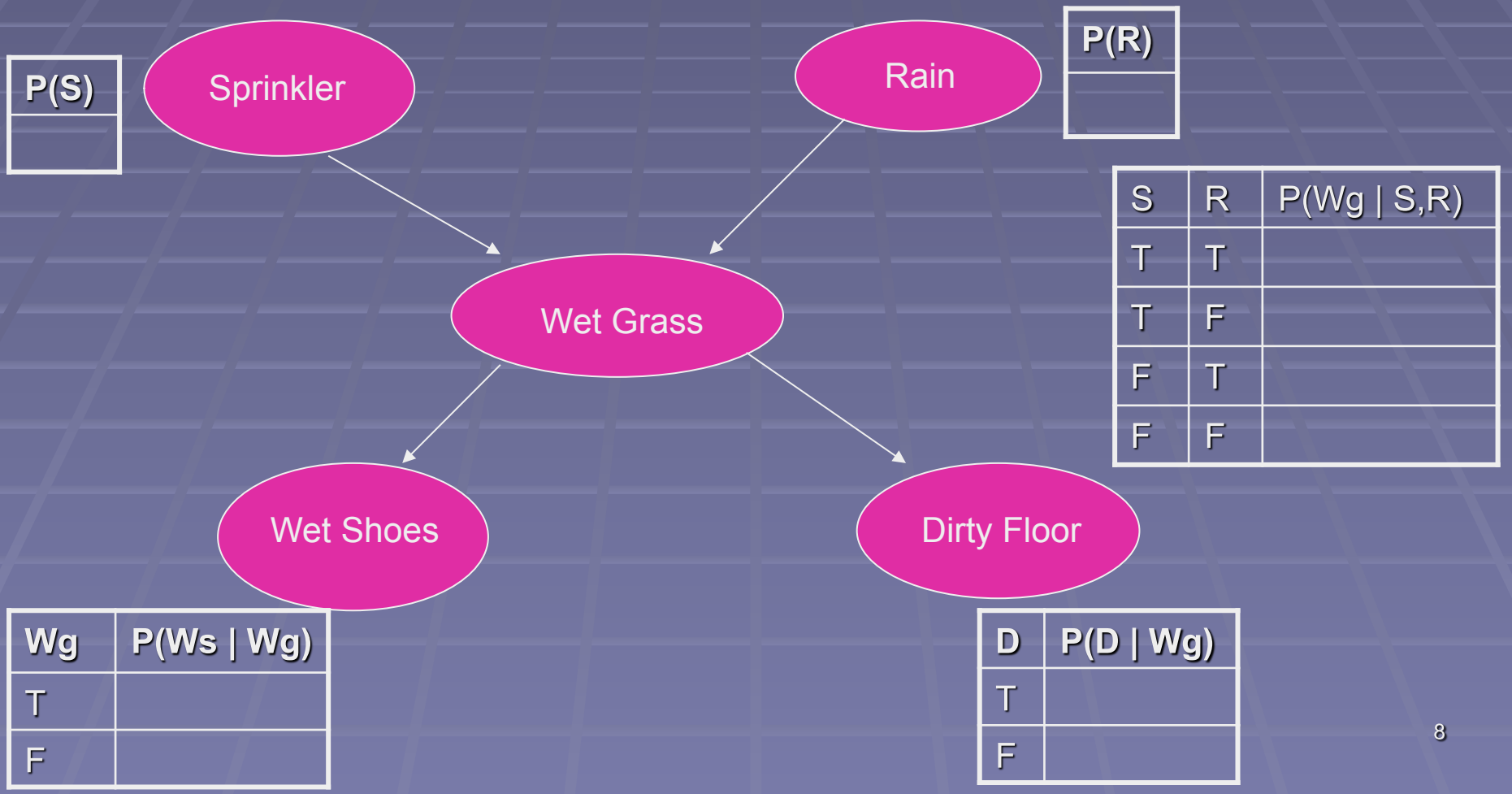
→ Network topology:

- A sprinkler can make the grass wet.
- A rain can make the grass wet.
- The wet grass can make the floor dirty.
- The wet grass can make the shoes wet.
- The wet shoes can make the floor dirty.

BNs - Example

→ directed acyclic graphs (DAG)

→ Conditional probability table (CPT)



P(S)

P(R)

S	R	P(Wg | S,R)
T	T	
T	F	
F	T	
F	F	

Wg	P(Ws | Wg)
T	
F	

D	P(D | Wg)
T	
F	

BN Learning

Four learning cases:

1. the goal of learning is to find values of the BN parameters that maximize the (log)likehood of the training dataset
2. with known structure and partial observability, one can use the EM algorithm to find loca

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