

FILMRISS

Forgetting In Lifted Models and Reasoning In Search of Solutions

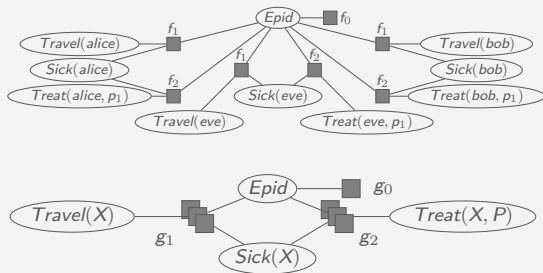
A collection of thoughts based on discussions with Jonas, Kai, and
Marcel during KI 2023

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(Lifted) Probabilistic Graphical Models (PGMs)

- ▶ Represent a full joint probability distribution over a set of random variables
- ▶ Set of factors over subsets of random variables based on (conditional) independences among them
- ▶ *Lifted*: indistinguishable factors represented by a single factor parameterised using logical variables (parfactor)



An Intuitive Idea What Forgetting Is in PGMs

Version 1

- ▶ Keep components implicitly in the (factorised) full joint but forget its explicit representation
- ▶ Full joint remains “the same” (possibly with new dimension) through valid mathematical operations on the (factorised) full joint

Version 2

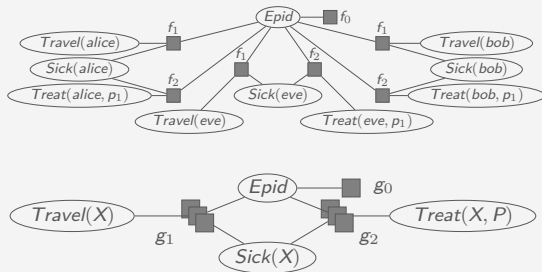
- ▶ Delete components from model
- ▶ Changes the full joint
 - * Is this closer to belief revision?

Alternative perspective

- ▶ Keep full joint unchanged regarding influences between unaffected components

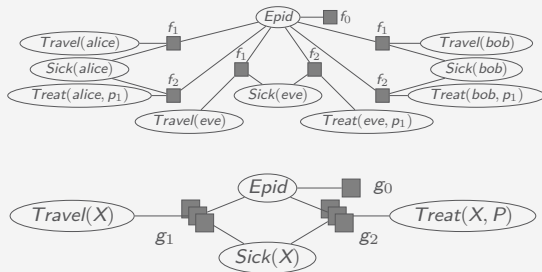
What is forgettable?

- ▶ Random variables
- ▶ Constants in lifted models
- ▶ Influences (direct / indirect)
- ▶ Factors
- ▶ Evidence over time
- ▶ Probabilities



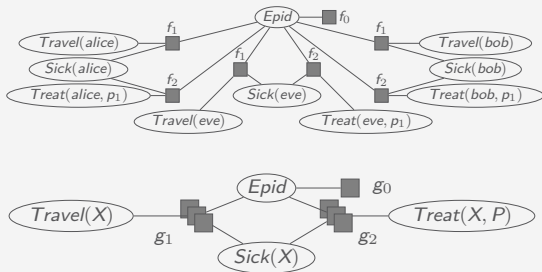
Forgetting Random Variables

- ▶ Changes the full joint probability distribution (dimension reduction)
- ▶ How to handle?
 - ▶ Sum out variable; keeps impact in the distribution
 - ▶ Delete all factors containing the variable; eradicates all local influences (possibly deletes further influences encoded in a factor)



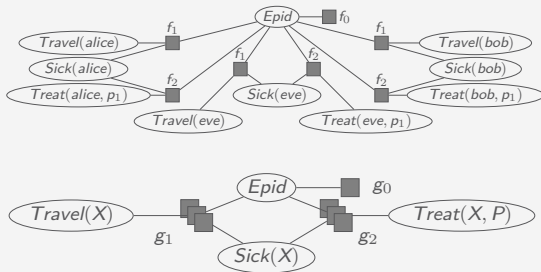
Forgetting Constants in Lifted Models

- ▶ Equivalent to forgetting a random variable in a propositional model
- ▶ Changes the full joint probability distribution (dimension reduction)
- ▶ How to handle?
 - ▶ Split off constant and sum out; keeps the impact of the constant
 - ▶ Delete constant from domain; eradicates local influences (deletes all factors grounded with constant)



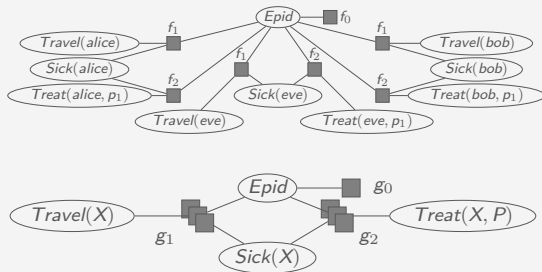
Forgetting Direct Influences (Edges)

- ▶ Changes the full joint probability distribution but keeps its dimension
- ▶ How to handle?
 - ▶ Sum out variable in a single factor? (not normal sum-out which requires variable to not appear in another factor; not a valid mathematical operation)
 - ▶ How do you change a factor if you want one dimension in a factor to disappear?



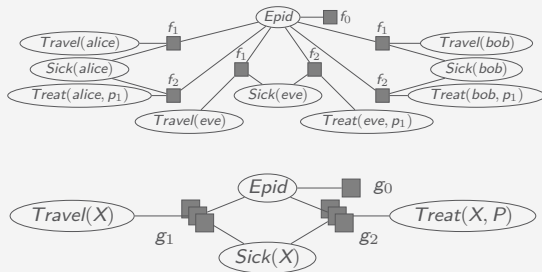
Forgetting Influences between Random Variables

- ▶ Changes the full joint probability distribution but keeps its dimension
- ▶ How to handle?
 - ▶ Some sort of backdoor criterion and deleting edges?



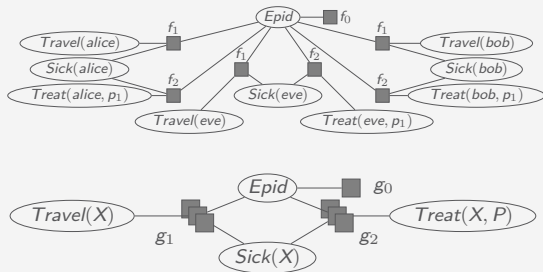
Forgetting Factors

- ▶ Changes the full joint probability distribution but may keep its dimension
- ▶ How to handle?
 - ▶ Sum-out factor (results in constant to keep around)
 - ▶ Delete factor
 - ▶ In lifted model, may correspond to removing a constant from a constraint of a parfactor



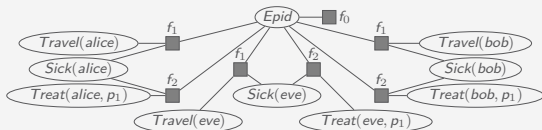
Forgetting Evidence Over Time

- ▶ In lifted models, relatively easy
- ▶ Not sure, if it is possible in propositional models
- ▶ How to handle?
 - ▶ A version of TAME: combine factors that are reasonably close to each other



Forgetting Probabilities

- ▶ Changes the full joint probability distribution but keeps the dimension
- ▶ How to handle?
 - ▶ Make probabilities “fuzzy”
 - ▶ Interval probabilities $[\phi - \epsilon, \phi + \epsilon]$?
 - ▶ Add Gauss (?) distribution to ϕ entries: $\phi + \mathcal{N}(0, \sigma^2)$?
 - ▶ Implies a degree of forgetting: smaller vs. larger ϵ, σ^2



Forgetting in PGMs

Version 1

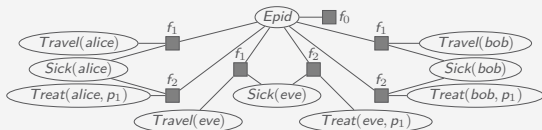
- Keep components implicitly, forget its explicit representation

Version 2

- Delete components from model

Components

- Random variables, constants
- Influences (direct / indirect), factors
- Evidence over time
- Probabilities



Markov Logic Networks (MLNs)

- ▶ Set of weighted first-order logic formulas Ψ
 - ▶ Semantics: ground, multiply, normalise
 - ▶ Semantics equivalent to that of parfactor graphs
- * Can we transfer forgetting operators directly to MLNs?
 - ** If so, what do the operations mean in parfactor graphs?

$(10, \text{Presents}(X, P, C) \Rightarrow \text{Attends}(X, C))$
 $(4.5, \text{Publishes}(X, C) \wedge \text{FarAway}(C) \Rightarrow \text{Attends}(X, C))$

