Computer Science Department, University of Bonn

Knowledge Graph Analysis

Exercise Sheet 9

Dr. Asja Fischer, Prof. Jens Lehmann

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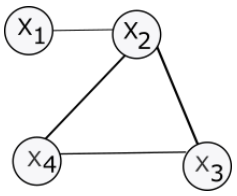
1 In Class

1. *Graphical models* combine statistics and graph theory. *Markov Networks* encode conditional independance statements in undirected graphs.

   ▷ Consider the following Markov Network:

   Are the follwing statements true or false?

   - Does X_1 depend on X_2?
   - $X_1 \perp X_3$
   - $X_1 \perp X_3 \mid X_4$
   - $X_1 \perp X_3 \mid X_2, X_4$

   ▷ Consider the set $X = \{X_1, X_2, X_3, X_4\}$ of random variables. Write down the Markov Network with the maximum number of edges, which satisfies the following:

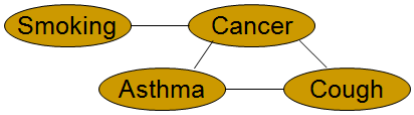
   - $X_1 \perp X_2 \mid X_3, X_4$
   - X_1 depends on X_4

- $X_3 \perp X_4 \mid X_1, X_2$

▷ A Markov blanket of a node A, denoted as $MB(A)$, is the set of neighbours of A in a Markov Network. Let B with $A \neq B, B \notin MB(A)$ be a node in Markov Network. Does $B \perp A \mid MB(A)$ hold?

2. *Factor Potentials*

Let the following Markov Network and factor potentials for the maximal cliques be given:



X_1 = Smoking	X_2 = Cancer	$\phi(X_1, X_2)$
False	False	0.5
False	True	1
True	False	0.5
True	True	1

X_2 = Cancer	X_3 = Asthma	X_4 = Cough	$\phi(X_2, X_3, X_4)$
False	False	False	1
False	False	True	2
False	True	False	2
False	True	True	1
True	False	False	0.5
True	False	True	0.5
True	True	False	2
True	True	True	2

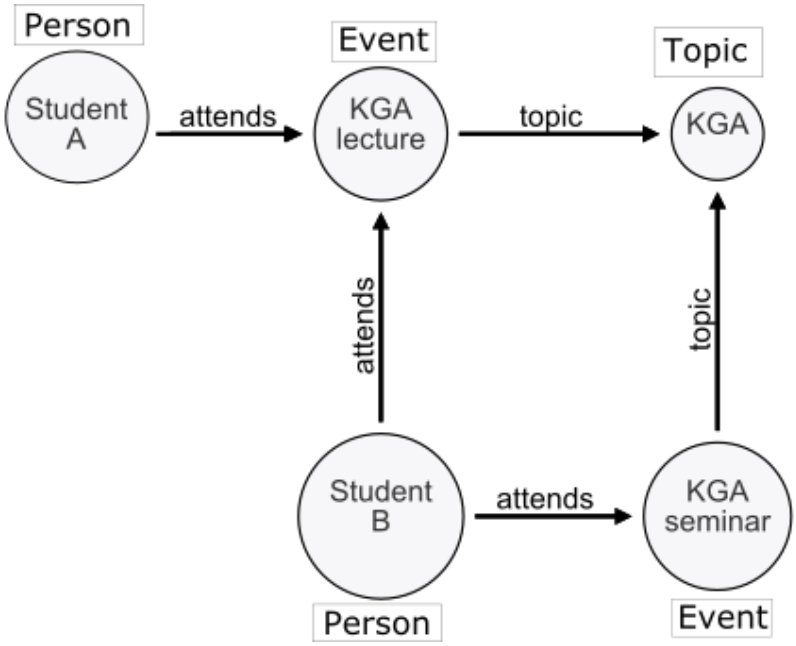
$$P(X) = \frac{1}{Z} \prod_{C_i \in C} \phi(C_i)$$

$$Z = \sum_{X} \prod_{C_i \in C} \phi(C_i)$$

▷ What is the value of the normalisation constant Z?

▷ What is the probability of the world w in which smoking=true, cancer=false, asthma=false, cough=true?

3. *Knowledge Graphs and Markov Networks*
Convert the knowledge graph below into a Markov Network dependency graph! To minimize the dependency graph, use the hard schema constraints that a) Person, Event and Topic are disjoint (i.e. have no common instances), b) attends has domain Person and range Event (i.e. the property connects persons to events), c) topic has domain Event and range Topic.



4. *Markov Logic Networks / Groundings*

   Use the knowledge graph from the previous graph with the following addition: There is a new relation *friendOf* and an edge with this relation from Student A to Student B. *friendOf* has domain and range Person. Consider this Markov Logic Network:

   1.4 $\forall P_1, P_2, E\ attends(P_1, E), friendOf(P_1, P_2) \implies attends(P_2, E)$

   1.8 $\forall P, E_1, E_2, T\ attends(P, E_1), topic(E_1, T), topic(E_2, T) \implies attends(P, E_2)$

   The probability of worlds in MLNs is computed by counting groundings of formulas. Using the entities in the previous task, write down a true and a false grounding for both formulas above with respect to the knowledge graph!

5. *Other*

   ▷ Assuming that each fact in a knowledge graph is a random variable: What dependency assumptions do Markov Logic Networks on knowledge graphs make?

   ▷ Which probability of being true does a Markov Logic Network formula with infinte weight have?

   ▷ What is weight learning in Markov Logic Networks used for?

   ▷ What is structure learning in Markov Logic Networks?

2 At Home

1. Model and run Exercises 2 and 4 using `http://www.pracmln.org`.